AGRICULTURAL ENGINEERING

MARCH 1943

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THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

New Ways Make

Grass Greater Than Grain

Grass now grows more feed per
acre, produces more meat and
milk, brings forth more wealth
than the same land will yield
with grain. Henceforth grass
shall no more be a poor relation
farming system, but the ace of all
Grassland farming means rota-
not built around wheat or corn,
ound grass . . . grass not merely
ugh, thin land, but the richest
ost level fields.

ss grown on fertile soils rich in
ble nitrogen, if grazed or cut
a few inches high, actually con-
as much protein as green
es. This is doubly important in
when protein concentrates may
rce and high-priced. In a few
it is ready to graze or mow again.

slopes too steep for cultivation,
s more than feed; it is the salva-
f soil. Contour furrows made
low or lister halt runaway water,
t from stealing soil, save it to
into subsoil and sustain grass
h during dry spells. And when
ins return, that same carpet of
shelters the soil from surface
n by pelting drops.

ovation of permanent pastures adds to their feeding capacity, often doubles it. Starved, root-bound sod is opened up with regular field tiller or spring-tooth harrow, preferably equipped with alfalfa teeth. In some conditions disk harrows can be used. Reseeding, in the small amounts desired, is done accurately with grass-seed attachment of a grain drill. Fertilizer attachment for the same drill, or use of a fertilizer drill, fortifies the soil for stronger growth of old and new grass.

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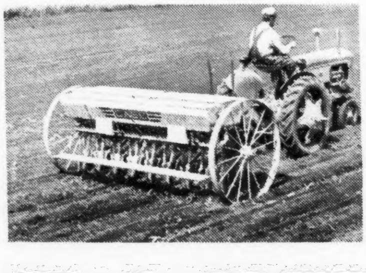

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AGRICULTURAL ENGINEERING

Established 1920

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Vol. 24, No. 3

EDITORIAL

Lesson Dearly Learned

IN THE effort to transform our economy from its peaceful and democratic ways to an effective war machine we have progressed for enough for some principles of practicality to emerge. One of them is that war expedients work pretty well when discretion for detailed decisions is vested in local boards or other bodies, and too often are fantastic failures when it is attempted to arrive at such decisions through application of formulas by remote control.

Selective service has worked out surprisingly well within the limits laid down for the local boards. So has the rationing of rubber and gasoline for passenger cars by local boards. In sharp contrast are the ludicrous allotments of gasoline for farm trucks allowed on the "certificates of war necessity" emanating from the centralized ODT office at Detroit, based on a bewildering misfit questionnaire and a 32-page "short form" of instructions for filling it out.

In one dairy county of which we have personal knowledge, order came out of chaos when a way was found to circumvent the formula. Farmers made no attempt to wrestle with the questionnaire; instead they brought it to the county agricultural committee or board. From direct personal knowledge and common sense this committee set down a proper amount of gasoline, and sent the form to a regional office of the ODT. This office simply added an OK and forwarded the forms to the central office at Detroit. It in due time issued the certificate which, on presentation to the local ration board, brought forth an appropriate ration card.

In that same county was a 35-cow farm operated by two women with the aid of hired help. War conditions took away all but one of their men, and he was not entirely able-bodied. To keep their herd in production they went through the red tape of getting permission to buy a milking machine and to wire the barn. On completion of installation they called on the power company to connect. Unrestricted when the installation was begun, such connection was now forbidden. Appeal to the central agency, this one in New York, brought only a "so sorry" on the ground that the 211 feet of wire from barn to pole could not be diverted from direct use in munitions. Red tape remained adamant, despite the obvious fact, remarked by a disgusted county agent, that if copper were not available they could get the milking machine to work with salvaged steel wire.

That was last fall. Recently the press has announced that discretion for such decisions is to be vested in a local committee or board. But in the interim, what has happened to the milk flow of the 35 cows, or to the herd itself? From the damage done in this case, no doubt multiplied by thousands throughout the country, we have learned a costly lesson. Let it not be forgotten in future choices between local and centralized discretion.

Saving Steel

SOME readers of these pages have observed that the single staple wherewith this and the prior issue of AGRICULTURAL ENGINEERING are held together is none too adequate for a technical journal permanently filed for repeated reference, however suitable it may be for the ephemerae of fiction. Curtailment from the former three, more recently two, staples is a gesture of saving critical metals. The steel saved by omitting a second staple is about equal, each month, to that in one-half of an automobile license plate.

"Pool-Hall Help"

ONLY those fully oriented in the rural scene will sense the significance of the phrase "pool-hall help," now used by farmers in some sections to indicate the kind of farm labor they are being driven to employ. In technical proficiency, in physical stamina, and in mental attitude it falls far short of the sons and seasoned farmhands who have been drained from America's agriculture.

Only the utmost care in training and supervising this kind of help can prevent serious losses, not only to crop and livestock production, but of mechanical and electrical equipment. It calls for the kind of training outlined in A.S.A.E. Past-President Fletcher's paper in these pages last month. All of us may well do what we can to push this proved way of job instruction training toward general adoption in agriculture.

Prepare for the Test

BEING engineers, members of the American Society of Agricultural Engineers are familiar with the various tests to which specimens of steel are subjected in order to determine their suitability for the various loads they must carry. We are constantly seeking new materials and improving the ones we have. The requirements are continually being raised. While in the test, the elastic limit must be reached if the true value is to be obtained. Steel has served us faithfully in the past, but for some purposes it has had to give way to other metals. The testing machine will never break, but the specimen must yield.

Our country, our army and navy, our industries are in a testing machine today. We did not greatly improve our specimen while the machine was idle so we must add to our metal while the test is on. We hope that enough metal has been added so that the machine and not the specimen will be the one that will break. The best generals will be found where the fighting is the hardest. Cast iron never did get to the largest machine.

Our test lies ahead. The testing machine will be the new frontiers of agriculture, the ragged edges of which are already here (see article by Dr. C. M. A. Stine in "New Pencil Points" for January 1943.) I would like to consider the younger members of A.S.A.E as specimens in the draft age for the test that is on its way. Let us analyze our specimens, starting training our generals, and establish some Atlantic Charters so that the fields of endeavor will forever expand and our steel will always be one of the critical metals of the day. Let's have some tungsten steel in our Society; the more proud of it we can be, the more top grade alloys will be attracted our way.

The road ahead is hard. We must fight as an allied nation and not as individual states. The old-time generals must do their share. It takes "V" letters from home to keep up the spirits of our fighting men. They must establish some "E" banner requirements and be ready with four stars when the invasions have been made.

> There's no thrill in easy sailing, when the skies
> are clear and blue.
> There's no joy in doing that which anyone can do.
> But there is a satisfaction that is mighty
> sweet to take,
> When you reach a destination that you thought
> you couldn't make.

W. A. JUNNILA

AGRICULTURAL ENGINEERING

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Can Farm Structures Be Standardized?

By Henry Giese

FELLOW A.S.A.E.

A COMPILATION in 1929 of farm building and equipment plans[5] prepared by state agricultural colleges and the federal department of agriculture revealed that 2812 plans were available to farmers. It would seem that with so many the field ought to be thoroughly covered and little should be lacking. On the contrary there was still much to be desired. The large number of plans reflected diversity of opinion on the part of designers and the exploitation of personal ideas not necessarily substantiated by experimental data. Widely divergent recommendations from contiguous states tended to confuse and mislead rather than to clarify and inspire confidence among the consuming public. Farmers had no adequate means for making a selection and young designers especially had little information upon which to prepare individual plans.

The result of this situation was often reflected in terms of poor construction and poor functional performances. Any effort toward prefabrication must of necessity be confined to local activities.

Standardization has been the keynote of progress in many other lines. Large organizations have been established primarily for the purpose of establishing standards. Among these are the National Bureau of Standards, the American Standards Association, the American Society for Testing Materials, and the National Board of Fire Underwriters. Other organizations such as the National Fire Protection Association devote a considerable proportion of their energies toward the adoption of standards for equipment and operation. The range of these standards is wide, both as to materials and equipment involved and the purpose for which standardization is sought.

Some of us at least can remember when the buyer of an automobile would not think of owning one similar to another in the community. If alike in make, it must differ in color, in the gadgets with which it was equipped, or even in body style. Gradually mass production methods prevailed, and standardization of parts was accomplished. The resulting effectiveness and low cost more than outweighed the personal satisfaction of having something different. Styles designed by experts were so much more pleasing that few would be willing to pay the price for individual consideration. There is, then, standardization which is done for the purpose of effecting economies of mass production.

Whenever a farmer undertakes to market almost any kind of crop or animal, he finds that certain tests are applied before a basis for settlement is reached. Other forms of merchandise are standardized and graded for the protection of both buyer and seller. In many cases these grades are nationwide in their acceptance. Thanks to this type of standardization, the slogan "Let the buyer beware" has become almost obsolete.

Again we have established standards of size and pattern. One of the problems in the attempted use of lumber recovered from old buildings lies in the fact that it is sized differently from that now obtainable. On the other hand, regardless of species or of mill from which the lumber is obtained, it is now milled to the American Lumber Standards so that it is usable along with other species or lumber from other mills without resizing. One can with confidence specify an 8d common nail of a $1\frac{1}{2}$-in No. 12 flathead screw and expect to secure a uniform product from any one of a large number of manufacturers.

Again we find standardization to facilitate the assembling of parts made in different factories. Automobiles are not made in their entirety in one factory. Millwork in a building is standardized to fit openings easily accomplished in masonry construction.

At a recent meeting the Iowa state fire marshal deplored the fact that particularly the larger towns of Iowa were not equipped with fire hydrants with standard hose threads. This is true in many other states as well. As long as this condition exists, it may be almost futile for a fire department from one city to go to a conflagration in another, because their equipment would not be usable after they arrived. Public safety then may be a purpose of standardization.

One could go on almost indefinitely to give examples of standardization in other fields and of different types

Many small structures like this are now prefabricated in the lumber yard and moved to the farm. Standardization is necessary to secure satisfactory performance and the economies of mass production

Paper presented December 7, 1942, at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill. A contribution of the Farm Structures Division. Author: Professor of agricultural engineering, Iowa State College.

according to the purpose for which it has been accomplished.

There has been some standardization in the field of farm structures. Years ago the cross section of the dairy stall was standardized, enabling equipment manufacturers to make partitions which would fit. Lyle[5] reported standard sizes for drawings and blueprints recommended by the Standards Committee of the American Society of Agricultural Engineers in 1914. In 1933 the agricultural engineers in 15 Middle West states made some progress toward standardization of farm buildings by the preparation and publication of the Midwest Farm Building Plan Service. In the northeast, western, and southern regions of the country similar plan services were developed later.

However, nothwithstanding these and others which I have doubtless overlooked, there is comparatively little standardization in the farm building field. In a maze of plans being distributed by the federal department of agriculture, state agricultural colleges, and commercial groups, the prospective builder has little to guide him in his choice or to direct his management program later.

Strahan[8,9] in two splendid articles published in AGRICULTURAL ENGINEERING laid the groundwork for economic studies which would establish the true relationship between farm buildings and the farmer's pocketbook. The individual farmer suffered annually serious losses of corn in storage until the ever-normal granary program brought the federal government face to face with the waste resulting from poor storage. I need not tell you of the splendid results from the study made once the magnitude of the problem was recognized.

One-third or more of the pigs farrowed never get to market. Should we have the temerity to ask why? Experienced feeders of livestock report shrinkage following blizzards. More feed, labor and time are required to regain the loss. Poultry and hogs when chilled huddle together in a corner attempting to keep warm and eat less when they should be eating more. These are but a few of the many aspects to the problem. Let us divert our attention from the "trees" and take a look at the "forest." If buildings bear an economic relationship to farm operation, let us discover and evaluate it. Let us then set standards which will result in improved performance, better construction, longer life and lower use cost.

Let us consider, what elements of farm buildings can be standardized. It is quite probable that we will not find a counterpart for all phases even among the few illustrations given from other fields. On the other hand, the possibilities are so great as almost to baffle the best efforts now available due to personnel and other limitations.

Perhaps the first choice is by type. Buildings can be standardized as complete structures, or as undertaken by the American Standard Association[1], namely, "the standardization of parts without standardization of the buildings." In the past there have been definite attempts to standardize complete structures, particularly in the housing of poultry. This has been deemed necessary in the formulation of extension programs and in some efforts toward prefabrication. Unless this is done with great care and based upon adequate fundamental data, it is likely to be misleading and unsatisfactory. It is my belief that as a Society we will not want to go beyond the standardization of the parts, whereas as individuals or commercial groups interested in prefabrication there may be a definite desire to go to the full extent of standardization of the building. It may be said, however, that the personal element is or should be present in less degree in farm service structures than in some other buildings, notably the dwelling, and hence it may be not only possible but also highly desirable to carry standardization further than should be done in the design of the other buildings referred to. Obviously some standardization is necessary if typical building plans are to be made available by state agricultural colleges and the federal department of agriculture.

Standardization can be classified roughly according to character as follows:

1 For improved service (functional)
2 To resist applied loads
3 For convenience in operation
4 For better utilization of materials
5 For better design, harmony, and balance
6 For better presentation to a fabricator often not highly skilled in building from working drawings.

While these groups probably can not all be arranged in order of importance, perhaps improved service is the one to head the list. After all, what could be more important than that the building should serve its intended purpose. I have little fear of contradiction when I say that all too often this result has not been secured in the past. Personal desires of the owner have received greater consideration than the needs dictated by service. This has been in part the result of a dearth of information. If the owner knows what he wants and the hen or the dairy cow cannot speak her needs, whose desires will prevail?

Among the factors to be considered under this same heading are temperature, relative humidity, and rate of air movement (commonly termed air conditioning), as well as light and space requirements. There is also the matter of economy of feed. Temperature conditions definitely affect feed consumption. Feed cost is a major item in the raising of livestock. Little consideration has yet been given to housing as a matter of feed conservation.

Another item under the heading of improved service is the conservation of the building. Unfavorable environmental conditions may result in condensation on walls and ceiling with resulting deterioration.

Notwithstanding the great importance of these factors, there is now wide divergence of opinion relative to the values which should be used in design and little factual data available.

Another type of needed standard relates to resistance to the various loadings to which the several parts of a structure may be subjected. Among these are trusses, beams, girders, floor construction, crib and bin walls, etc. Standardization may be limited to assumptions used in design, or it may be extended to include the design itself. An example of this is the self-supporting roof. Many designs have been employed and a large number still adorn the sheets of our building plan services. Some have been effective and some have not. Even though all now submitted for farm construction were structurally adequate, there would still be an incentive to seek economies in materials and labor, the simplification of cutting and the elimination of unnecessary parts, and design for understanding and compliance by the farm carpenter.

Again we might establish standards for interrelationship of the several elements either of a building or a farmstead with special reference to convenience and economy of labor and of operation.

There is also the better utilization of materials. This problem is perhaps more acute in farm construction than in any other due largely to the type of labor usually employed on the farm. Various attempts have been made to standardize dimensions for various materials. It is scarcely possible

(Left) The rafters in this streamlined barn were mill-fabricated. Advantages of prefabrication depend upon the establishing of functional and structural standards • (Above) Simplified and standardized construction resulted in low labor cost on this hog-house.

to design a barn leaving choice of structural materials to the owner, because of variation in sizes of the component parts when made from different materials.

Much criticism has been directed toward the designers of farm buildings, because of violation of accepted principles of design and lack of harmony among the several buildings on the farm. Conceivably it would be possible to establish relationships which should be observed by the designer.

Still another type of standardization would have a definite bearing upon the degree to which ideas growing out of research will find acceptance in farm construction. I mean standardization for the purpose of securing better presentation. A building plan is perhaps our most effective means of transmitting results of research to the farmer. Considerable ingenuity is required to adapt principles presented in a bulletin to actual construction. The researcher should be able to do this more effectively than anyone else.

Many of our farm building plans have been little more than suggestions for the arrangement of space, leaving structural problems at the mercy of the builder. A plan should be sufficiently complete that the ideas of the designer are fully covered. This must be accomplished without undue complication and confusion to those not highly skilled in reading plans. There should be standards for presentation which would include (1) drawings to be presented, (2) symbols, (3) arrangement, and (4) sheet size.

From the foregoing, I believe it is apparent that there are two types of standardization. One may be arrived at by arbitrary acceptance such as the size of sheet to be used in presenting plans, while the other is fixed by scientific principles. We can no more secure best results by violating nature's laws of life than we can repeal the law of gravitation or arbitrarily make the numerical value of π a whole number.

Again there is the choice between complete standardization of a building for purposes of mass production and the standardization of details leaving assembly into a working unit in the hands of a designer.

In general I am convinced that the principal reason for lack of effort in farm structures lies in the lack of appreciation of the service rendered. All too often buildings are constructed down to a price rather than up to a performance. The cost of a building is readily apparent while the economies from owning it may be completely overlooked, and again, because of a dearth of fundamental data upon which to base design, there may be little or no correlation between the original cost of a building and the service rendered by it.

There has been a definite shortage of personnel even in normal times and small funds for basic research.

Another serious problem has been the lack of teamwork. While we have our semiannual A.S.A.E. meetings and do accomplish considerable through committee activity, actually each one of us has a full responsibility at home and little time available for cooperative work. Recognizing the difficulty in securing cooperation among college and experiment station workers dependent entirely upon their own resources, the Advisory Council on Research in Farm Structures appointed by the Secretary of Agriculture in 1929 recommended[3] "that an agricultural engineer of adequate training be designated by the Division of Agricultural Engineering, U. S. Department of Agriculture, to organize and direct the program and whose duties and responsibilities in general shall be—

"1 To develop a program of coordinated research of farm structures having in mind projects of pressing national and regional significance.

"2 To maintain intimate contact with farm structures workers at the various state colleges and experiment stations for the purpose of stimulating their interest in proper projects and of coordinating their efforts with others working along the same line as a means of avoiding unnecessary duplication of effort.

"3 To foster a spirit of active cooperation between national and state research institutions in the structures field.

"4 To maintain a close relation with industrial, technical, and educational agencies through direct contact with a permanent advisory council representing these interests in order properly to interpret the specific needs of industry and agriculture to the research agencies.

"It is the conclusion of your council that only through this well-defined program can proper solutions to all the vital problems in this field be reached."

To date no action has resulted from the recommendations of the council.

Failure to show greater progress in the past does not reflect a lack of interest upon the part of those who have been engaged in farm structures work, whether it be research, resident or extension teaching, production, or sales. It has been the author's belief for some years that the development of standards for farm buildings is so important and so extensive that the full time of at least one man should be devoted to it. Existing agencies could be much more effective if their efforts were coordinated. Much unnecessary duplication as well as unnecessary gaps result from independent action. If properly synchronized, the problems could be attacked in part by the several research

agencies, relieving each one of the responsibility for attempting to cover the entire field.

The Farms Structures Institute has made a good start in stimulating interest upon the part of publicly supported agencies. To be most effective, however, it should extend its membership to other commercial groups and to representatives from the federal and state organizations, and it should not be dependent for direction upon persons who have full-time responsibilities elsewhere.

The problems of standardization are so many and varied that even with greatly increased facilities it would take a long time to cover the field. It would seem logical then to canvass the possibilities rather thoroughly as a prelude to the formulation of any definite action program.

The questionnaire circulated among the state agricultural experiment stations recently by the U. S. Department of Agriculture could well constitute a starting point. Discrepancies in statements made by the stations point out controversial points and consequently needed research On the other hand, agreement among the stations does not necessarily indicate the possession of factual data. As a procedure I would propose the following:

1 Compilation of a comprehensive list of information desired

2 Check off data now available based on research and hence beyond the range of controversy

3 Prepare a list of needed information with some effort toward the arrangement in order of importance

4 Decide what degree of standardization is desirable (a) by the Society as a whole, (b) by state and federal agencies publishing bulletins and circulating plans, and (c) by commercial groups manufacturing materials or engaged in partial or complete prefabrication

5 Prepare a plan of action.

The poultry science group has recently made a start in their field in the publication of a comprehensive list of projects[7]. While such a list does not assure coverage, it does help to clarify the whole problem and provide the basis for further activity.

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Agricultural Engineers Needed in Malaria Control

THE editor has obtained permission for publication of a letter on the above-named subject which will be of particular interest and significance to agricultural engineers. It was prompted by a request for suggestions for the program of a meeting of the Southeast Section of the American Society of Agricultural Engineers. The writer of the letter is Fred W. Knipe (Member of A.S.A.E.), who for more than twelve years was engaged in research work in the control of malaria under the direct auspices of the Rockefeller Foundation, his work being carried on mostly in the Balkans and in India. Only recently he returned to the United States, and is now employed in the bureau of malaria control of the Florida State Board of Health. In his letter he indicates that malaria control is a subject in which agricultural engineers should be interested, and with reference to his experiences mentioned above goes on to say:

"These experiences have long since led me to believe that engineers engaged in malaria control should be basically trained in agricultural engineering. Malaria is essentially a disease of rural areas. Its control almost invariably has something to do with the reorientation of water on or pertaining to agricultural developments. For instance, in the Balkans my work dealt largely with drainage problems and with stream control. In India, it dealt with problems in irrigation, particularly with the possibilities of the introduction of an intermittent irrigation system in rice-growing areas, and the effect of such method of irrigation on that crop. In so far as I know, our activities along this path of agricultural research were among the first experiments ever attempted. Such work is, as I see it, largely a problem in agricultural engineering, as is most involvement of malaria control and water.

"Frankly, wherever I have worked on malaria control, wherever I have visited the activities of others doing similar work, I have always believed that an agricultural engineer is the engineer properly trained for the job. In other words, the economics of agriculture and the economics of malaria are frequently very closely allied. Personally I have never completed a job of malaria control in which the economic improvement as it affected agriculture has not in itself more than paid the cost of the control measure.

"These facts are so outstanding that many medical staffs, under whom malaria research and control are usually carried on, agree as to the importance of an agricultural training for an engineer employed in malaria control.

"Here in the United States the malaria control problem is not so acute as in most tropical and subtropical countries. Nevertheless it is a problem so obvious and important that very considerable personnel is now employed in its solution, especially in areas of troop concentrations. It is in such work that I am at present engaged, with the State Board of Health of Florida. Fortunately I have one recently graduated agricultural engineer working here with me.

"It is my belief that a greatly enlarged field of activity in malaria control will be opened in many countries of the world after the present war is terminated. It is my desire to see agricultural engineers assume the engineering responsibilities in this field. The life of a 'malaria engineer,' as I am now known, permits only a life of important public service, but also one of wide-range travel and adventure. . . .

"My main thought in bringing up this subject is the possibility of acquainting members of the Society with the possibility of future employment in this field. . . . I cannot help but believe that a future exists in this field, particularly for the young agricultural engineer who is possessed with an adventurous spirit. I know what a demand exists for such men at the present moment."

A Bulldozer for General-Purpose Farm Tractors

By Virgil Overholt, C. B. Richey, and L. B. Morehead
MEMBER A.S.A.E. MEMBER A.S.A.E.

THERE is a need for inexpensive equipment that will make it possible, with the general-purpose farm tractor, to build efficiently terraces and diversion ditches. In spite of the attention given to erosion control during the past ten years, only a small percentage of the needed terraces and diversion ditches have been built. The most common equipment for such work in Ohio has been the township road grader which often is in a generally poor state of repair. Self-propelled, county-owned road maintainers have been used in some cases. They can do a satisfactory job but are usually not available when needed and many counties will not allow their use for private work.

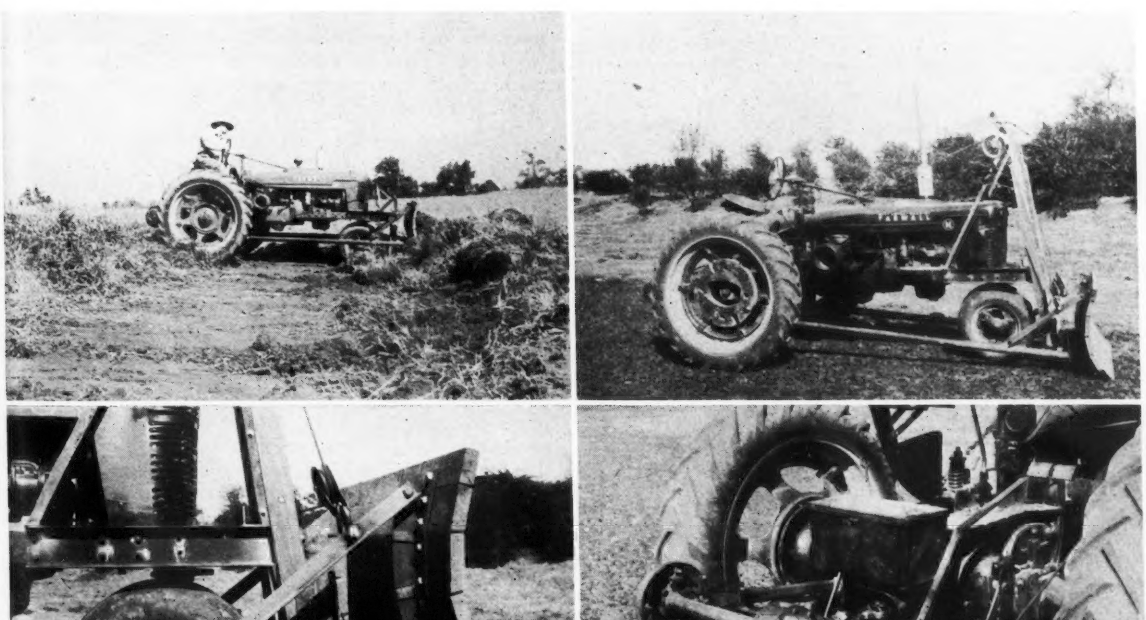
As an approach to the problem, the authors decided to try building a bulldozer for a general-purpose farm tractor because a bulldozer is very efficient for moving dirt short distances, and with it a ridge of sufficient height for even a large diversion ditch can be easily constructed. Crudely constructed homemade bulldozers for farm tractors are being very successfully used for backfilling tile ditches in several localities in Ohio and Indiana.

It was realized that a rubber-tired farm tractor would not have sufficient traction to cut the dirt loose, but it was hoped that if the necessary dirt was plowed loose the bulldozer would shove it down the slope and make a ridge. It was also realized that a strong and easily controlled power lift would be needed to ease the blade up when the tractor stalled and also to carry the dirt up to the ridge top.

The first model was built early in January 1942 and it worked nicely except that a higher lift was needed. The 5-ft width seemed to be about right for the two-plow tractor used. In October 1942, the lifting frame was changed as shown in the accompanying illustrations and further tests did not show any defects. The present lift is probably higher than necessary for a bulldozer, but it was made this way because it is hoped that later a manure fork and dirt scoop can be attached in place of the bulldozer blade.

The bulldozer is pushed by two pieces of $2\frac{1}{2}$-in pipe which hinge at the tractor drawbar. The cutting edge of the blade is a section of a grader bit supported by a 5-in steel channel. Above the channel 2-in oak planks are used for the blade. They bolt to 3-in steel angle uprights, which are welded to the channel at the bottom and are attached to the push pipes about 8 in above the cutting edge of the blade. Braces of $1\frac{1}{2}$-in steel angle extend from the top of the uprights back to the push pipes.

Paper presented December 8, 1942, at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill. A contribution of the Soil and Water Conservation Division. Authors: Overholt and Richey, agricultural engineers, Ohio State University; Morehead, agricultural engineer and farmer, Franklin County, Ohio.

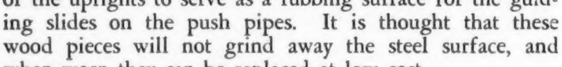


Four views of a bulldozer designed for a general-purpose farm tractor. (Upper left) Building a diversion ditch with the bulldozer. (Upper right) Improved model bulldozer with high lift. (Lower left) This close-up shows the blade and one of the push pipes. (Lower right) The power lift made from an old automobile rear axle was driven by the power take-off

The lifting power is furnished by the tractor power take-off which operates an automobile rear axle with a cable-winding drum on one side, using the system developed for a buck rake lift. (See AGRICULTURAL ENGINEERING for June 1942, pages 196 and 197.) This rear axle serves as a clutch, a reduction gear, and a brake, being controlled by a footlever. When the footlever is depressed half way, the winding drum brake is released and the bulldozer will drop due to the force of gravity. When the footlever is depressed all the way, the brake on the side opposite the winding drum is tightened and the differential action causes the winding drum to turn, thus lifting the blade. When the footlever is not depressed a spring pulls it up and tightens the brake on the winding drum, thus supporting the blade in any desired position.

Uprights bolted to the front of the tractor frame support the pulleys for lifting the blade, and keep it in place laterally. Hardwood strips are bolted to the outer sides of the uprights to serve as a rubbing surface for the guiding slides on the push pipes. It is thought that these wood pieces will not grind away the steel surface, and when worn they can be replaced at low cost.

Arc-welded construction was used throughout. The blade and push pipe assembly weighs 397 lb, the lifting frame 163 lb, and the auto rear axle lift 208 lb, making a total weight of 768 lb. The whole outfit can be attached to the tractor by two men in 30 min.



Cross section of a diversion ditch made with the bulldozer described in this paper.

When tried in the field, this bulldozer showed ability to move dirt with unexpected speed. Under favorable conditions it was possible to make three passes per minute. A net width of 2 to 4 ft was handled per pass, depending on the amount of dirt in the ridge. On the basis of 45 min of working time per hour, this would indicate a capacity of 270 to 540 ft per hr, not including plowing or smoothing the ridge which can be done with the same tractor without removing the bulldozer. Tile ditches can be backfilled at the rate of 600 to 700 ft per hr.

The amount of dirt needed for the ridge can be calculated and enough furrows plowed to furnish this dirt. A backfurrow is thrown up on the desired channel line, and the necessary number of rounds made. Care should be taken to plow loose all the dirt at the backfurrow to avoid stalling the tractor when bulldozing. In the case of large diversion ditches, it may be desirable to plow and use the bulldozer a second time to secure a deeper channel.

One of the outstanding advantages of the outfit is its flexibility. A few extra passes will give extra ridge height at depressions or extra depth at high spots in the channel. Different types of cross sections can be constructed, and it is easy to follow sharp curves.

This machine is not presented as a perfected job, but rather as an approach to the problem of enabling the farmer to build his own terraces and diversion ditches easily and economically with his own equipment. It is hoped that other agricultural engineers will investigate its possibilities under their particular conditions.

EDITOR'S NOTE: Copies of this paper, to which has been added construction procedure and detail sketches of the bulldozer, may be obtained by writing Ohio State University, Agricultural Engineering Dept., Columbus.

"Production Rating of Farmers Under Wartime Conditions"

TO THE EDITOR:

SINCE FARM crop records have been more or less of a lifelong hobby with me, I was much interested in the articles, entitled "Rental Rates for Farm Machinery", "Production Rating of Farmers Under Wartime Conditions", and "Wartime Allocation of Farm Machinery", in AGRICULTURAL ENGINEERING for January. I wish to congratulate the committee of the American Society of Agricultural Engineers that set up a score card by which the efficiencies of individual farmers may be compared. This material, as well as the fair rental data, will be badly needed in the near future.

As a result of over 25 years of farming experience, I believe the greatest problem in the renting and exchange of farm machinery is the fact that we have a few farmers in every community who terribly abuse our so-called "good neighbor policy". They practically operate their farms on borrowed equipment, which is usually returned broken or badly worn due to abuse and lack of grease — if returned at all. Usually you have to go after it. If they will do this to machinery furnished them out of the goodness of your heart, I shudder to think what they would do to equipment they were hiring. Such a farmer is irresponsible and poor pay, so the owner of a machine would likely not be able even to collect the rental fee, let alone damages for breakage due to misuse. If your committee can figure out ways and means of handling this guy, I believe there would be a great increase in days of use per year of farm machinery through renting and exchange, to the advantage of the war effort and all parties concerned.

In looking over the farm production rating form (AGRICULTURAL ENGINEERING for January 1943, page 20) it struck me that corn is given an extremely high rating in proportion to its value per acre and man-hours needed in its production. We raise a large acreage of corn and soybeans, so I will take these crops as an example. Although the USDA lists soybeans as a war crop and is urging greater production, it figures 12 acres of soybeans to a war unit as against 5 acres of corn. Then in the farm production rating form, even a greater discrepancy exists. Taking average Iowa yields, an acre of corn produces 60 bu, or $0.6 \times 90 = 54$ weighted production units. An acre of soybeans produces 25 bushels, or $0.25 \times 45 = 11.25$ weighted production units. Thus we see that an acre of corn gives five and a half times as many weighted production units as soybeans. Although corn yields over twice as much and is only worth half as much as beans, it gets twice as many production units per 100 bu.

Consider another angle, man-hours per acre. My production records, averaged for a number of years, show that corn and beans take almost exactly the same man-hours per acre, 6.9 man-hours for corn and around ½ man-hour more for beans, due to more hand work required in cutting out big weeds. In fact, we use exactly the same operations in preparing ground, planting, and tending beans. Three-fourths of a man-hour more is used in harvesting corn than beans, so, for all practical purposes, we may say that the man-hour factor is a standoff.

I am aware that in some localities soybeans are planted with a grain drill and tended with a rotary hoe, weeder, or harrow, thus reducing the man- (Continued on page 83)

A Study of Garden Irrigation

By L. H. Schoenleber

MEMBER A.S.A.E.

SINCE 1938 the department of agricultural engineering and the department of horticulture at Kansas State College and the Kansas Committee on the Relation of Electricity to Agriculture have sponsored a garden irrigation project at Manhattan, Kansas. The primary objectives were: (1) To determine the value of irrigation for farm vegetable gardens, (2) to determine which method of irrigation is best to use, (3) to study installation costs, power requirements, volume of water required, and the amount of labor required to irrigate by the different methods, and (4) to determine the effect of light and frequent irrigations as compared to heavy and less frequent irrigations on crop yields.

Methods and Equipment Used. Five different methods of irrigation were used, namely, furrow, overhead spray, rotary spray, perforated pipe, and subirrigation. Plots used were 45 by 100 ft with a 5-ft border between plots. The equipment used consisted of the following:

1 For the furrow irrigation one 22-ft section of light-weight, gated metal pipe, as shown in Fig. 1, and 30 ft of 2-in rubber hose and hand tools such as shovel and garden hoe were used.

2 One hundred feet of 1-in pipe with 33 No. 0 spray nozzles, as shown in Fig. 2, with seven 1-in pipe supports 4 ft high, and 30 ft of $1\frac{1}{2}$-in rubber hose, were used on the overhead spray irrigation. One-half of the plot was irrigated at a time, using an average of four different settings.

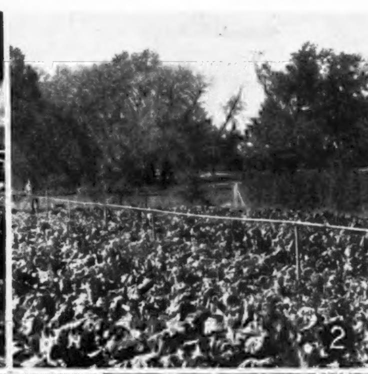
3 One hundred feet of light-weight, portable pipe line with 5 rotary sprinklers (No. 2 Rainbird) with $\frac{1}{8}$-in nozzles mounted on 30-in risers at intervals of 20 ft, as shown in Fig. 3, was used on the rotary-spray irrigated plot. Each rotary sprinkler covered a circle of about 45 ft in diamater.

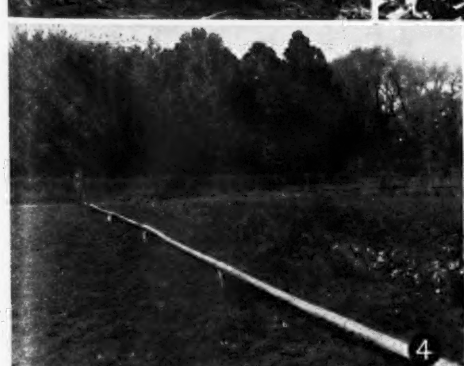
4 Five sections of 3-in galvanized, quick coupling, 20-ft length was used on the plot irrigated by perforated pipe, type C. This method is sometimes called Perf-o-rain. The pipe had a series of small holes drilled into it at 30-in intervals. The perforated pipe system is shown in operation in Fig. 4.

5 Equipment used on the subirrigated plot consisted of tile laid level from 10 to 12 in underneath the surface of the ground and 4 ft apart. Approximately 1200 ft of tile, consisting of 4-in clay tile, 2-in cement tile, and 2-in stabilized earth tile were used. The water distributor and meter box for the subirrigation plot is shown in Fig. 5.

Paper presented December 8, 1942, at the fall meeting of the American Society of Agricultural Engineering at Chicago, Ill. A contribution of the Soil and Water Conservation and the Rural Electric Divisions. Author: Assistant professor of agricultural engineering, Kansas State College.

AUTHOR'S NOTE: The author wishes to express his appreciation to S. W. Decker, associate professor of horticulture, Kansas State College, for his assistance in assembling and interpreting crop yields.





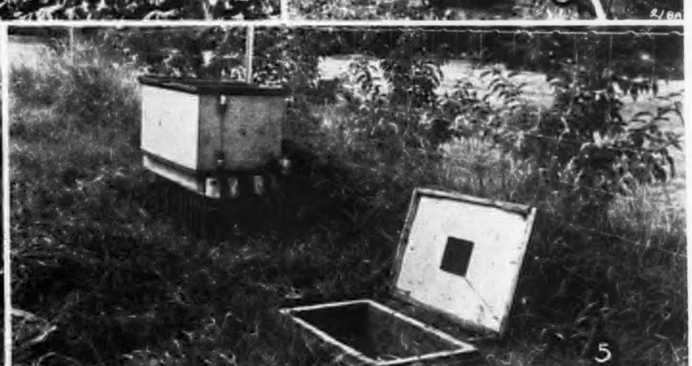


Fig. 1 This shows the use of light-weight, gated metal pipe for furrow irrigation • Fig. 2 The setup for overhead irrigation • Fig. 3 Portable pipe line with rotary sprinklers • Fig. 4 This shows the perforated pipe system of irrigation • Fig. 5 Water distributor and meter box for subirrigation plot. Equipment consisted of tile laid level 10 to 12 in below surface and 4 ft apart

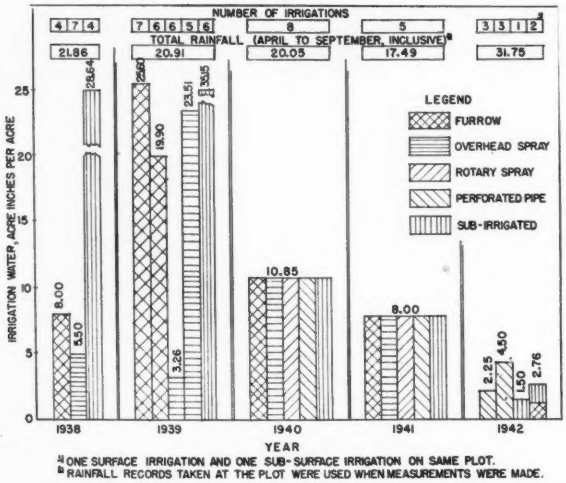


Fig. 6 Amount of irrigation water applied per year, 1938 to 1942 inclusive

Soil Characteristics. Soils found on the plots were classified as silt loam for the surface soil. The subsoil was classified as clay loam. The soils on these plots were not generally considered the best to irrigate. After irrigation the surface soils were a little heavy to work satisfactorily, and if they were not worked at the p:oper time they became hard and worked up with difficulty. The wilting coefficient for the surface six inches averaged approximately 10.4 per cent and the subsoil averaged approximately 11.7 per cent. The field-holding capacity was quite uniform and averaged 30 per cent for the surface six inches and 34 per cent for the subsoil.

Climatic Conditions. A study of the drought periods during the growing season as related to supplemental irrigation in Kansas reveals that 55 to 103 days without effective moisture may be expected yearly in some part of the state and that additional water available for crops is desirable. A rain with effective moisture is considered as 1/4-in or more rain in 24 hr in April and May, and a 1/2-in or more rain within 24 hr in June, July, August, and September. The nine consecutive days following an effective rain were considered as days with effective moisture. The tenth consecutive day without an effective rain was considered one day without an effective moisture, the eleventh as two days, etc.

The maximum rainfall during the growing season occurred in 1942 with 31.75 in and the least in 1941 with 17.49 in. All of the rain that occurred during the growing season was not effective moisture. During each growing season three or more drought periods existed which is considered normal for this section of the state. The duration of these drought periods varied from one day to 48 days. The maximum length of period was 48 days in 1940 to 16 days for 1942. The total number of drought days is a good measure for determining the amount of irrigation water needed each year; these ranged from 45 in 1942 to 69 in 1940. The total evaporation, wind movement, and average daily temperature are also indices of the water requirement during the growing season. A summary of the climatic conditions at Manhattan, Kansas, during the growing season from 1938 to 1942, inclusive, is shown in Table 1.

Amount of Water Applied. The amount of irrigation water applied to the garden plots varied from year to year, as shown by Fig. 6. During the growing seasons of 1938 and 1939 the amount applied was equal to the amount deemed necessary to obtain maximum crop yields or an apparent good irrigation.

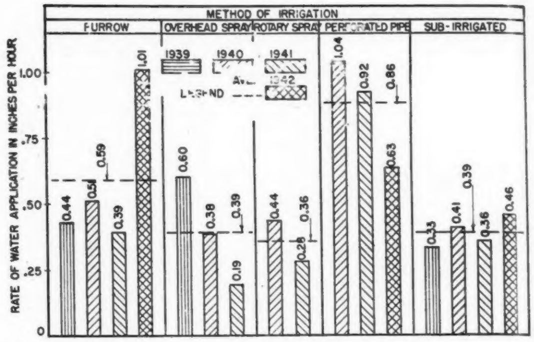


Fig. 7 Rate of water application in inches per hour, 1939 to 1942 inclusive

During 1940 and 1941 the amount of irrigation water applied was equal for all plots. The amount needed on the furrow-irrigated plot served as a guide for all other plots. During the 1942 growing season the amount of water applied varied. One plot received light and frequent application while others received heavy and less frequent applications. If we assume a minimum of 30 in of water properly distributed is needed during the growing season for efficient plant growth, then additional water other than rainfall would be needed for the years 1938, 1939, 1940, and 1941. A comparison of crop yields indicates that supplemental irrigation water was beneficial during these years. The average amount of rainfall for all years was 22.41 in. If we assume all this rainfall were effective precipitation, then at least 7.59 in of additional water would be required. Usually much of the rainfall is not in sufficient quantity to be effective and of value for

TABLE 1. SUMMARY OF CLIMATIC CONDITIONS AT MANHATTAN, KANSAS, FOR GROWING SEASON, APRIL 1 TO SEPTEMBER 30, 1938 TO 1942, INCLUSIVE

	1938	1939	1940	1941	1942
Total rainfall, in	21.86	20.91	20.05	17.49	31.75
Total number of drought days	63	57	69	62	45
Number of drought periods	6	4	3	7	5
Longest period without effective precipitation, days	36	34	48	31	16
Total evaporation from free water surface, in	56.412	62.472	58.541	53.314	47.730
Total wind movement, miles	18,774	18,194	16.527	16,331	16,963
Average wind movement, mph	4.27	4.38	3.85	3.80	3.93
Average mean temperature, deg F	72.3	72.6	70.4	72.6	70.4

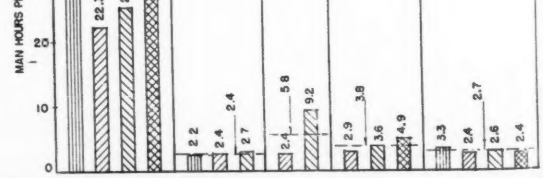


Fig. 8 Average labor required to irrigate for all irrigations in hours per acre, 1939 to 1942 inclusive

plants. During the growing season 5 in or more rainfall was not effective precipitation. This means that approximately 12 in of supplemental water would be needed each year normally.

Rate of Applying Water and Labor Required. The rate of applying irrigation water and the labor required for each irrigation during each year was obtained on all plots. The rate of water application for different methods of applying water is shown in Table 2 and Fig. 7.

TABLE 2. AVERAGE RATE OF WATER APPLICATION IN INCHES PER HOUR FOR 1939 TO 1942, INCLUSIVE

Year	Method of Irigation				
	Furrow, in per hr	Overhead spray, in per hr	Rotary spray, in per hr	Perforated pipe, in per hr	Sub-irrigated, in per hr
1939	0.44	0.60			0.33
1940	.51	.38	0.44	1.04	.41
1941	.39	.19	.28	.92	.36
1942	1.01			.63	.46
Average	0.59	0.39	0.36	0.86	0.39

The highest rate of water application was on the perforated-pipe irrigated plot, or an average of 0.86 in per hr. The rate of application during 1942 was the lowest for this system. A smaller quantity of water on one of the perforated-pipe irrigated plots eliminated the necessity of stopping the system and allowing time for water to penetrate the soil. When applying continuous high rates of irrigation water on the soil with this system, it was necessary to stop the system to allow water to penetrate into the soil so that no runoff occurred.

The furrow-irrigated plot ranked next with 0.59 in per hr. During 1942 the rate was nearly twice that of any other year which was attributed to the smaller area of the plot. Less time was required for the water to run the full length of the small area. One furrow irrigation was applied on a portion of the subirrigated plot to add moisture for germinating the seed.

The rate of applying water by overheard spray, rotary spray, and subirrigation was all approximately the same, or 0.39, 0.36, and 0.39 in per hr, respectively.

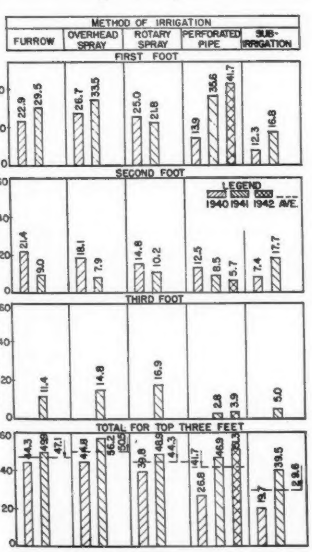
The amount of labor per acre to irrigate plots using different irrigation systems is shown in Table 3 and Fig. 8. The plots irrigated were 0.1 acre or smaller. Labor required to irrigate these experimental plots may not be indicative of the labor required to irrigate larger areas. However, trends shown might be expected. The furrow-irrigated plot required the most labor, with an average labor required for all irrigations of 33.6 hr per acre. During 1942 the labor required was nearly twice that of former years, which undoubtedly was due to irrigating a very small portion of the subirrigated plot. The rotary-spray irrigated plot ranked next in labor required for irrigation, with 5.8 hr per acre. Frequently the rotary spray units caused trouble and would not rotate, which increased labor requirements. The perforated-pipe irrigated plot required 3.8 hr per acre to irrigate. The subirrigated plot required 2.7 hr per acre and overhead-spray ranked last, requiring 2.4 hr per acre.

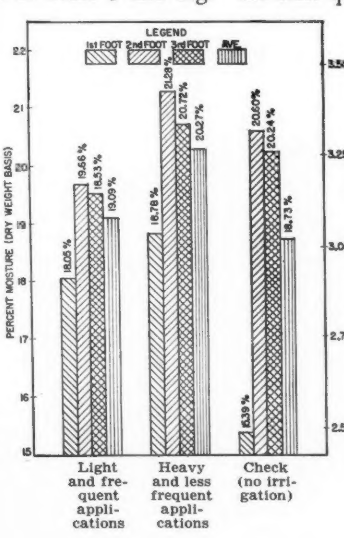
TABLE 3. AVERAGE LABOR REQUIRED IN HOURS PER ACRE TO IRRIGATE (ALL IRRIGATIONS) 1939 TO 1942, INCLUSIVE

Year	Method of Irigation				
	Furrow, hr per acre	Overhead spray, hr per acre	Rotary spray, hr per acre	Perforated pipe, hr per acre	Sub-irrigated, hr per acre
1939	29.2	2.2			3.3
1940	22.3	2.4	2.4	2.9	2.4
1941	25.1	2.7	9.2	3.6	2.6
1942	57.8			4.9	2.4
Average	33.6	2.4	5.8	3.8	2.7

Water Application Efficiency. The amount of irrigation water retained in the major portion of the root zone area of the crops was determined during 1940, 1941, and 1942. Soil samples were taken of each of the top three feet of soil, both before and after irrigation on each plot to determine the moisture content. The ratio of the water retained to the water applied was determined, which is called water application efficiency. The water application efficiency for all irrigations during 1940 to 1942, inclusive, is shown in Table 4 and Fig. 9.

In most cases more water was retained in the top foot when compared to the amount retained in the second or the third foot. This may be dependent on one or more of such factors as condition of the soil, type of soil, type of crop, rate of water application, etc. It is apparent that the least quantity of water would be retained in the root





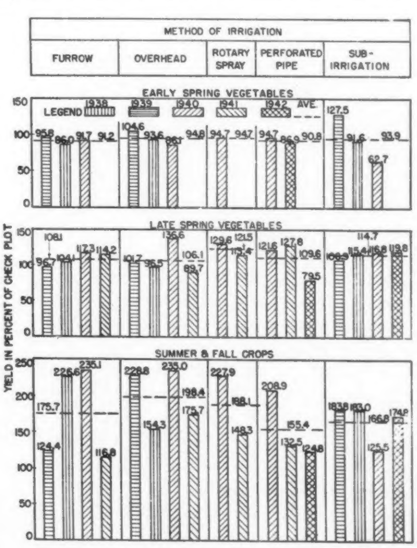


Fig. 9 (Left) Water application efficiency for all irrigation during 1940, 1941, and 1942 • Fig. 10 (Center) Average moisture content of all samples for first three feet for check plot, plot irrigated with light and frequent applications, and plot irrigated with heavy and less frequent applications of irrigation water, July 20 to August 24, 1942 • Fig. 11 (Right) Vegetable garden yields on plots irrigated by different methods in per cent of check plot yield (no irrigation), for the years 1938 to 1942 inclusive.

TABLE 4. WATER APPLICATION EFFICIENCY IN PER CENT FOR TOP THREE FEET FOR THE YEARS 1940 TO 1942, INCLUSIVE

	Method of Irrigation				
	Furrow, per cent	Overhead spray, per cent	Rotary spray, per cent	Perforated pipe, per cent	Sub.-irrigated, per cent
			First Foot		
1940	22.9	26.7	25.0	13.9	12.3
1941	29.5	33.5	21.8	35.6	16.8
1942				41.7	
Average	26.2	30.1	23.4	30.4	14.5
			Second Foot		
1940	21.4	18.1	14.8	12.5	7.4
1941	9.0	7.9	10.2	8.5	17.7
1942				5.7	
Average	15.2	13.0	12.5	8.9	12.5
			Third Foot		
1941	11.4	14.8	16.9	2.8	5.0
1942				3.9	
Average	11.4	14.8	16.9	3.3	5.0
			Total		
1940	44.3	44.8	39.8	26.4	19.7
1941	49.9	56.2	48.9	46.9	39.5
1942				51.3	
Average	47.1	50.5	44.3	41.5	29.6

zone area where subirrigation was used. The irrigation tile were installed one foot below the ground surface which made it difficult to wet the top foot of soil. The water application efficiency on the subirrigated plot was the least, or 29.6 per cent. The plot irrigated by overhead spray system retained the most water, or 50.5 per cent. The furrow irrigated plot retained 47.1 per cent; rotary-spray irrigated plot 44.3 per cent, and the perforated-pipe irrigated plot 41.5 per cent of the water applied. In general those plots having largest water application efficiency produced largest crop yields when equal quantities of water were applied.

When irrigation water is applied in correct amounts and at the right time it will be of greatest value for maximum plant production. It is impossible to foretell how long a drought period will last or when effective precipitation will occur. If irrigation water is applied at regular periods, undoubtedly more water may be available for plant use than is necessary at some time during the season. During 1942 one drought period of two days occurred followed by heavy rains. Irrigation water was applied before the heavy rains occurred and harmful effects were evident when the plants were inspected.

In 1942 two plots were irrigated, using the perforated pipe. One plot received 0.75 in of water and the other plot received 1.5 in during each irrigation. The plot receiving large applications was irrigated only one-half as often as the plot receiving light applications. The average moisture content for all soil samples for the top three feet of soil on each plot is shown in Fig. 10. The approximate amount of water retained for the different per cent moisture content may be obtained from this chart. The average specific gravity for all soil samples and for all plots was used to determine the inches of water retained. The plot receiving large applications of water retained more moisture in the top 3 ft when compared to moisture on the check plot which had no irrigation water and plot receiving small applications. The average moisture content for the second and third foot on the check plot was higher than for the plot receiving light applications. However, the average moisture content for all top 3 ft was higher for the plot receiving light applications. The average water application efficiency for the plot receiving the largest applications was 53.6 per cent, and 49.0 per cent for plot receiving the small water applications.

Vegetable Yields. The garden vegetables grown were generally the same as those that might be found in the average Kansas farm garden. The crop yields were placed in three general groups, based on the time of maturity. They were grouped for comparison as (1) early spring, (2) late spring, and (3) summer and fall crops. Some crops are planted early in the spring and mature as late spring or as summer or fall crops. In other cases, summer and fall crops were planted at intervals so as to lengthen the harvest season of fresh vegetables.

In general, the early spring vegetable crops mature and were harvested without encountering drought periods. Irrigation water was always applied on the plots after the early spring vegetables were harvested. The yields for early spring crops on the irrigated plots were generally below that of the check plot. A comparison of vegetable yields on plots irrigated by different methods are shown in Table 5 and Fig. 11. The reduced yields for early spring vegetables on irrigated plots may be attributed to the poor physical condition of the soils and to a reduced supply of available nutrients due to heavier yields produced in previous years.

TABLE 5. COMPARATIVE VEGETABLE YIELD UNDER DIFFERENT METHODS OF IRRIGATION IN PER CENT OF YIELD ON CHECK PLOT

CHECK PLOT (no irrigation) = 100 PER CENT

	Method of Irrigation				
	Furrow, per cent	Overhead spray, per cent	Rotary spray, per cent	Perforated pipe, per cent	Sub.-irrigated, per cent
		Early Spring	Vegetables*		
1938	95.8	104.6			127.5
1939	86.0	93.6			91.6
1940	91.7	86.1	94.7	94.7	62.7
1941					
1942				86.9	
Average	91.2	94.8	94.7	90.8	93.9
		Late Spring	Vegetables		
1938	96.7	101.7			106.9
1939	104.1	96.3			115.4
1940	117.3	136.6	129.6	121.6	116.8
1941	114.2	89.7	113.4	127.8	119.8
1942				79.5	
Average	108.1	106.1	121.5	109.6	114.7
		Summer and	Fall Crops		
1938	124.4	228.8			183.8
1939	226.6	154.3			183.0
1940	235.1	235.0	227.9	208.9	125.5
1941	116.8	175.7	148.3	132.5	174.8
1942				124.8	
Average	175.7	198.4	188.1	155.4	166.8

*Irrigation water was applied after early spring vegetables were harvested.

The need for irrigation of late spring crops varies with the season. Some seasons the natural rainfall was ample for the crop while in other seasons irrigation was beneficial. During the period of these studies irrigation has generally been of some value; however, the benefit was not great, seldom causing more than a 25 per cent increase in yield.

Summer and fall crops seldom escape damage resulting from drought periods. The use of irrigation on crops of this group has produced marked increase in yield. An increase of 16 to 135 per cent was obtained. For all years the plot irrigated by the overhead system showed an average increase of 98 per cent; the perforated pipe had an average of 55 per cent and showed the lowest for all systems. In general, 1940 yields were highest for all plots.

During the seasons of 1940 and 1941 equal quantities of water were applied using the different methods of irrigation. Water was applied after the early spring crops were harvested. When equal amounts were applied, the average yields for late spring, summer, and fall vegetables were 59.2 per cent more for overhead irrigated plot, 54.8 per cent more for the rotary-spray irrigated plot, 45.8 per cent more for the furrow-irrigated plot, 37.2 per cent more for the perforated-pipe irrigated plot, and 34.2 per cent more on the subirrigated plot, when compared to the check plot receiving no irrigation water.

(Continued on page 80)

Labor Saving by Sugar Beet Mechanization

By E. M. Mervine
MEMBER A.S.A.E.

IT IS now practical to thin sugar beets mechanically and to harvest them mechanically. Mechancial thinning makes it possible to get along with from one-tenth to one-half the present number of hand laborers. Mechanical harvesting can be done with approximately one-sixth of the present labor requirements. Both thinning and harvesting require peak labor loads, so these two mechanizations fit well into the requirements for raising sugar beets.

Experiments in mechanizing the sugar beet crop have developed some interesting facts, as follows:

1 It is possible by using small seed balls to obtain a near approach to single-germ seed balls.

2 It is possible to grind large seed balls to a small size and approach single-germ seed balls.

3 It is possible to build planters that will give a practically even distribution of seed balls in the furrow, insuring a high percentage of single plants (in contrast to present high percentage of multiple plants).

4 It is practical to use much smaller planting rates than heretofore, making it unnecessary to do so much thinning.

5 It is practical mechanically to thin these stands. A mathematical measure of the beet stand may be obtained and from that a positive predetermined size for a mechanical thinner may be foretold.

6 Mechanical thinning reduces the labor more than half.

7 Mechanical topping of beets is scientifically regulated resulting in superior quality to that obtained by average hand labor.

8 Mechanical harvesters leave the by-product, "tops", in better condition for cattle feed than does hand labor.

9 Mechanical harvesters miss fewer beets than hand harvesters.

10 Mechanical harvesters are built at a cost that makes their operation economically sound.

11 Mechanical harvesters make possible elimination of more than half the present labor requirements.

Nine years ago engineers of the then Bureau of Agricultural Engineering started "mechanical thinning" experiments. There was not much encouragement for mechanizing this operation; labor was plentiful and applying mathematical formula to a beet field looked unreasonable. However, the several years of experimentation have developed techniques that have proved valuable, and now that labor is no longer plentiful the method is being generally accepted.

Paper presented December 8, 1942, at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill. A contribution of the Power and Machinery Division. The material used in this paper was obtained in cooperation with the Colorado and California agricultural experiment stations (USDA No. 3747; Colorado Agricultural Experiment Station Scientific Series No. 156). Author: Agricultural engineer, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture.

A mechanical beet harvester which continuously harvests over three acres per day

The "stand" of beets may be measured accurately by stating the percentage of inches or rows in which beets are found, either singles or multiples. A mechanical thinning tool may cut, from the row, a definite proportion of inches, and with mathematical accuracy leave a desired stand.

The proportion of single beet plants to multiples depends of course on the distribution of seeds in the row as left by the planter. Hence it is obvious that the development work incorporated improvements in planter design. Single-seed ball planters designed to place single-seed balls, rather than groups of seeds, at regular intervals in the furrow make the mechanical thinning process much more practical. Many of the implement manufacturers are now building planters which will handle the small screened seed or the ground small seed, in each case placing single-seed balls in the furrow. The result is that approximately 70 per cent of the plants are singles.

Three methods may then be followed:

1 Complete mechanical thinning
2 Mechanical thinning tempered with some labor
3 Hand labor (long-handled hoe in contrast to "stoop" labor)

Complete mechanical thinning may be done in from one-tenth to one-fiftieth the time now consumed by the usual contract laborer. The result is that, as would be expected, the per cent of singles in the final stand remains about the same as with the planter stand, i. e., approximately 70 per cent. This will possibly cut the final yield from that obtained by hand thinning where practically every remaining beet is a single.

Mechanical thinning (less drastic than in the first method) followed with thinning by laborers using the long-handled hoe may, or may not, improve the strictly mechanical method. If the laborer is very careful, he will improve the percentage of singles. If, however, the laborer swings his hoe without using considerable care, he may produce results not much, if any, different from those obtained by machine only. Naturally the amount of care he uses determines the amount of time which he may spend on the job, ranging from approximately one-half to two-thirds the time now spent by "stoop" laborers, doing all the work by hand.

Long-handled hoe thinning without any previous machine work gives the laborer latitude in choosing where he will strike with his hoe. With 70 per cent of the planted beets growing as singles, it is quite possible for him to leave a perfect stand of single beets. This is frequently accomplished by careful laborers, but too often the man on the hoe soon becomes automatic in his operation and produces results no different from

the machine. The time required for this operation ranges from two-thirds to an equal amount of time consumed by the normal "stoop" laborer.

The results of an elaborate study of mechanical thinning trials this year are as follows:

	Man-Hours Per Acre	Yield in Tons Per Acre
Complete mechanical thinning	2.45	12.24 + .45
Mechanical thinning plus long-handled hoe	11.6	11.40 + .27
Long-handled hoe	15.6	11.47 ± .31
Customary hand block and thin	27.2	12.17 ± .42

The significant result is that there is no difference in yield between the mechanically thinned field and the hand blocked and thinned field, and the former required less than 10 per cent as much labor as the latter.

Mechanical Harvesting. Mechanical harvesting of beets is very close to realization. An approach to the satisfactory machine is one built to "top" the beets in the ground, satisfactorily dispose of the tops in windrows for subsequent use as cattle feed, lift the topped beets separated from loose soil, and place several rows of finished beets in a windrow for loading. Satisfactory loaders are also built for loading into a truck directly from the windrow.

This most recent harvester has gone through several stages of development, but the original idea was worked into a machine and beets have been harvested on a production basis. As a result several machines were manufactured and tried in different beet growing areas. Several "bugs" were eliminated. For this past season, fifteen machines were built and sold in as many areas. Most if not all of them did their work with surprising success.

The quality of topping was a little more than 1 per cent better than customary hand topping. This means that the grower sells 1 per cent more of his total tonnage. Based on a 12-ton crop, he sells 240 lb more of beets per acre which at $9 per ton means $1.08 more per acre. The harvester picks up the severed tops and places several rows of tops in a windrow. This is done without mixing the tops with soil, and in the windrow they cure advantageously.

The beets are lifted with practically standard lifting points, except that they are longer so that a pair of spring-mounted beater wheels may grasp the beet and throw it on conveyors. In light soils a complete separation of soil and beets is attained, permitting the beets to be windrowed. Mechanical loaders pick up the windrowed beets and load them into trucks after a still further dirt separation.

Mechanical harvesting can be done by one man on the tractor-harvester; in some cases alone. Where there is some difficulty a second man following the harvester picks up missed beets. Under extreme conditions two men might be needed for this work.

The capacity of the harvester is conservatively 3 acres per day. Several of the harvesters have day after day harvested more than 4 acres per day.

Assume 15-Ton Crop	Man-Hours Per Acre Present Methods	Man-Hours Per Acre Harvester System
Lifting	1.0 to 4.45	0
Hand pile and top	30.0 to 41.0	0
Hand load and haul	4.05 to 9.2	
Mechanical harvester		3.3 to 9.9
Mechanically load and haul		2.8 to 2.8
	35.05 to 54.65	6.1 to 12.7

A Study of Garden Irrigation

(Continued from page 78)

During the season of 1940 the crops were planted so as to have a maximum of variety at all times. This required that beans and similar crops be planted throughout the summer and early fall months. The quantity of moisture used in subirrigation was sufficient to maintain growth and fruiting of established crops, but moisture was not carried near enough to the surface of the soil to germinate newly planted seed and establish the crop during drought periods. This is probably one reason the subirrigated plot did not show as high yields as the other plots.

During 1942 less attention was given to crop production while special attention was given to water distribution and the correlation of soil moisture to crop yields. Crop yields were compared on the plot receiving light water application and the plot receiving heavy application. The effectiveness of light and heavy irrigations for 1942 are shown in Table 6. Both plots were irrigated, using the perforated pipe. In general, the plot receiving heavy applications produced the highest yield.

TABLE 6. COMPARATIVE VEGETABLE YIELD ON PLOTS IRRIGATED WITH PERFORATED PIPE, LIGHT AND HEAVY IRRIGATIONS, IN PER CENT OF YIELD ON CHECK PLOT, 1942
CHECK PLOT = 100 PER CENT

	Light irrigations	Heavy irrigations	Check (no irrigation)
Early spring vegetables*	80.7	93.1	100
Late spring vegetables	72.5	86.6	100
Summer and fall vegetables	121.8	127.8	100

*Early spring vegetables were harvested before irrigation water was applied.

SUMMARY

1 Five different methods of irrigation were used: furrow, overhead spray, rotary spray, perforated pipe, and subirrigation.

2 The normal number of drought periods occurred every year; however, the number of drought days was above normal for all years except 1942.

3 Approximately 12 in of supplemental water annually would be needed for maximum garden crop yields under normal conditions.

4 The average rate of applying water for all years was 0.86 in per hr using perforated pipe, 0.59 in per hr using furrow, 0.39 in per hr using overhead spray and subirrigation, and 0.36 in per hr using the rotary spray system.

5 The furrow irrigated plot required an average of 33.6 man-hours per acre to irrigate for all years. This was approximately ten times the labor required to irrigate by other methods.

6 The labor required to irrigate these small plots by different methods may not be indicative for labor required to irrigate large areas; however, these trends could be expected.

7 In most cases more water was retained in the top foot of soil for plant use when compared to the amount retained in the second or third foot of soil.

8 The average water application efficiency for the top three feet of soil was 50.5 per cent on overhead spray, 47.1 per cent on furrow, 44.3 per cent on rotary spray, 41.5 per cent on perforated pipe, and 29.6 per cent on the subirrigated plot.

9 In nearly every case where plots received equal quantities of water, the plot having highest water application efficiency also produced the largest yields.

10 The average water application efficiency for the plot receiving the large applications was 53.6 per cent, while the plot receiving small water applications was 49 per cent. Both plots were irrigated by perforated pipe.

11 In general, all plots irrigated produced increased yields.

12 Early spring vegetable crops matured and were harvested without need of irrigation water. Irrigation water was always applied after early spring vegetables were harvested.

13 Irrigation was usually beneficial for late spring, summer, and fall crops.

14 During two years when all irrigated plots received the same quantity of water, the average yields for late spring, summer, and fall vegetable crops were 59.2 per cent more for overhead-spray irrigated plot, 54.8 per cent more for the rotary-spray irrigated plot, 45.8 per cent more for the furrow irrigated plot, 37.2 per cent more for the perforated-pipe irrigated plot, and 34.2 per cent more on the subirrigated plot, when compared to yields on the check plot receiving no irrigation water.

A Farm Machinery Repair Program

By C. N. Turner
MEMBER A.S.A.E.

FARM labor is the most critical shortage facing New York state farmers. Since farm machinery is the only real substitute for labor, farmers are going to be seriously handicapped in producing food in 1943. Everyone knows that, if we are given fewer new machines, less efficient machines will have to do the work. This will result in more labor being required or less food being produced. It is obvious to many of us that the farmer cannot keep up food production.

The foods which seem to be the most critical require more hours of labor and machine use than the grain foods of which there seems to be a larger supply.

Our experience in New York in 1942 with substitute labor has proven that machinery cannot compensate for the lack of ability and capacity of the experienced labor which has left the farms. Many reports have come to us of machines that have been damaged and have become idle as a result of inexperienced help. Therefore, the shortage of labor and steel for new machinery demands that everything possible be done to keep existing equipment on farms in the best possible operating condition.

A reduction in the supply of new machinery brings about an increased demand for repair and adjustment service on the part of farmers. These demands could not be met by New York dealers even with the man power and facilities they had before the war. One important small grain (including soybeans) and dairy county is without a single full-time repair shop at present. Farmers already cannot even secure an adequate supply of repair parts.

Because of this critical situation the New York State War Council allocated funds for an "emergency farm machinery repair program" which was started on January 5, 1942. Fifteen district agricultural engineers were hired, trained, and equipped to conduct an intensive educational program in the repair, adjustment, and maintenance of farm machines. These engineers were trained with personnel and funds of the agricultural engineering department at Cornell University. The supervision of the fifteen engineers is under the regular agricultural engineering extension specialists. The state was divided into fifteen machinery districts of three or four counties each. A county agricultural agent chairman for each district, with the aid of the district engineer, plans and organizes the program and the engineer's schedule and conducts the publicity program.

The program was planned and organized in cooperation with the state agricultural defense committee, state USDA war board, the state education department and the farm machinery company branch managers.

The fifteen district agricultural engineers were furnished either a pickup or panel truck to transport themselves and their complete set of repair tools. This equipment was selected on the basis of fifteen years' experience with farm machinery and tractor repair schools conducted by the extension members of the agricultural engineering department. In addition to the usual small tools, the engineer has a welder, a portable flexible-shaft grinder, "portopower" hydraulic press equipment, an electric drill, and a collection of special tools for sprayers, combines, and tractors. They are provided with truck maintenance and travel funds for all necessary transportation in their counties, as well as for coming to the college for special training at two-week intervals. They perform many repair jobs right on the farm, but we all prefer that they diagnose the trouble, make needed adjustments, but turn field repair work over to the dealer service man when available. It has been interesting to note that the majority of SOS farm visit calls have been on troubles on which the farmer failed to get satisfactory help from his dealer or other service agency. Needless to say these are the most difficult troubles but each one is solved to our complete satisfaction as well as that of the owner.

Each district engineer calls a meeting of the county agricultural agents in his district to plan his schedule and discuss the types of meetings for a three months' period. About six months are devoted to indoor discussion meetings and repair clinics and the other six months to field adjustment and operating demonstrations during the season of each machine's use.

Farm Machinery Repair Clinics. The county agricultural agent sends a card to his membership to secure information regarding the interest they might have in bringing one or more machines to a centrally located garage or shop to overhaul them under the supervision of the district engineer. In the community where the interest seems best, a farm machinery committee is appointed to see if a heated building can be secured and if at least ten farmers will agree to bring a plow, harrow, grain drill, mower, manure spreader, sprayer, grain binder, corn harvester, or ensilage

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cutter to the clinic and overhaul it during a scheduled five-day period.

During February and March of 1942 sixty-seven farm machinery repair clinics were held with a total attendance of 7,459. Approximately 1200 machines were brought to these clinics and overhauled by the farmers. Special sessions were held for the discussion of common repair parts needed for all machines and the importance of ordering them early. The machines brought to the clinics proved to be excellent examples of needed repairs and adjustments. These dismantled machines showed the importance of proper lubrication and adjustment for trouble-free operation.

Also during February and March, 474 one-day lecture demonstrations were held. Over two-thirds of these meetings were held in dealers' places of business. A total 9,712 farmers came to find out how to check their machines for needed repair parts and to learn how to make adjustments and to take better care of their equipment. At least two different types of machines were selected by the farmers to be on hand for discussion and demonstrational purposes. Many farmers came to these meetings to satisfy their curiosity, but every man learned something new about a machine which he felt he knew from A to Z.

THE ENGINEERS CONDUCTED THREE-HOUR MEETINGS FOR TUNING UP FARM TRACTORS

Tractor Tuneup Meetings. About the first of April the engineers were scheduled for a series of three-hour tractor tuneup meetings.. Usually three or four popular makes of tractors were brought to the meetings by farmers or dealers for a thorough checkup of valve clearance, ignition timing, carburetor adjustments, chassis and engine lubrication, care of air cleaner and oil filter, and care of the rubber tires. The instruction given at these meetings dealt entirely with the care and adjustments to be made by the farmer or his operator rather than repair work which can best be accomplished by the service man with special tools. Over 50 per cent of the tractors brought to these meetings were out of adjustment in ways which would waste fuel, lose power, and soon cause a costly repair.

Field Plow Adjustment Demonstrations. At plow adjustment field meetings from two to five tractor-plow outfits were assembled to be adjusted and checked for sprung beams as a demonstration of how good plowing could be accomplished. One hundred eighty-three demonstrations attracted 3,030 farmers during their busiest season. We have estimated that 75 per cent of the tractor plows brought to the demonstrations were out of adjustment so that the life of the steel points was reduced at least 50 per cent. Farmers still like to do good plowing, but the tractor plow seems complicated and after a certain amount of trial and error they give up and do the best they can.

Haying Equipment Meetings. Many of the meetings on haying equipment were held after supper and called twilight meetings because farmers were busy in the field.

At 94 field demonstrations on mowers, 1,576 farmers came to learn the important repairs and adjustments to make the mower run easier, thus saving fuel for tractor operation and eliminating sore necks on horses from tongue-heavy machines. Everyone has assumed that any farmer could operate a mower efficiently after using one so many years. The troubles are usually laid to the manufacturer of the machine and not to improper repair and adjustment.

The district engineer arrived at one of the field meetings on mowing machines to find that the farmer's machine would not cut the heavy alfalfa. Before a group of thirty-five farmers he explained the simple shearing action of the cutter bar and the importance of the alignment of the pitman and knife section. The machine had 3 in of lag instead of 1¼ in of lead. By using the Porto-Power the cutter-bar lead was restored in about thirty minutes. The mower then cut the alfalfa without a single stall. Such demonstrations are entirely new to farmers, and it convinced those attending that they needed to give more attention to certain adjustments for heavy mowing.

Hay rope splicing was often demonstrated at mowing machine meetings. Hay rake and loader repairing were also discussed if time permitted.

The district engineers have assisted several farmers in constructing the "buck rake," to demonstrate what it can do for New York farmers. In addition 89 demonstrations were attended by 2,355 farmers who saw hay picked out of the windrow and transported to the barn by one man on an old auto, truck or regular tractor. The bulletin prepared by the department of agricultural engineering at Ohio State University was reprinted and over 8,000 copies were distributed.

Milking Machine Meetings. The dairy farmer uses his plow, mower, etc., relatively few hours during the year, but he uses his milking machine, water system, and electric motors every day of the year. Since this equipment makes a large contribution to the saving of labor and production of food, a special training school for the engineers was held in cooperation with manufacturers.

One of the engineers held a series of ten barn meetings in cooperation with a member of the animal husbandry staff. One hundred eighty farmers attended to find out how to locate and avoid troubles with their machines, how to clean them properly, and how to reduce their time of milking based on new research findings at the experiment station.

Grain Binder Adjustment Demonstrations. At 80 meetings on grain binders 810 farmers left their own fields to learn how to adjust the complicated binding mechanism so that they would not have to tie bundles by hand. Many grain binders are sold at junk prices because they fail to tie all the bundles. A few adjustments and sometimes a small part makes them as good as new. A binder which ties all the bundles is a great labor saver.

ADJUSTMENT DEMONSTRATIONS GAVE ENGINEERS OPPORTUNITY TO SHOW POSITIVE RESULTS

The results of farm visits and adjustment demonstrations are very gratifying because any bundles left untied gives the engineer an opportunity to show positive results by correct repair and adjustment.

Combine Adjustment Demonstrations. The use of combines in New York state is a new venture. Hundreds of new operators doing custom work know little about the principles of threshing grain. At 56 combine-adjustment meetings 815 operators and grain farmers attended to find out just what to expect from a properly adjusted machine. Many were surprised that the combine could be adjusted to thresh and clean the grain without throwing from 5 to 10 per cent of the crop back on the ground with the straw. Some machines had been operated two seasons on three or four different crops without the operator making a single adjustment. A good operator adjusts his machine at least twice a day in the same field.

Demonstration Truck and Wattmobile. The farm machinery demonstration truck was scheduled with the "wattmobile" (developed by Cornell agricultural engineers) during June, July, August, September, and part of October to emphasize the care, repair, and correct operation of both farm and home equipment. Two extension specialists of the regular staff have been conducting from one to three demonstrations a day for five days a week since it started on the

road. Labor-saving equipment is being exhibited and demonstrated. Eighty-eight demonstrations were attended by 5,499 rural people. The wattmobile emphasizes the electrical equipment and the demonstration truck emphasizes farm equipment.

Publicity. A full program of publicity has been carried on through newspapers, radio, and extension service letters and bulletins. Many excellent stories with pictures have been printed in local papers showing the work being done.

A summary of the results for the first six months of the farm machinery repair program in New York state is as follows:

1 The total attendance at all types of farm machinery meetings was 33,138. In addition to meetings 2,730 farm visits were made in response to requests from farmers for the solution to special machinery and equipment troubles. This is the best indication of farm acceptance of the program.

2 The reports from the district engineers show that they have personally assisted in the repair and adjustment of over 25,000 machines during their first six months in the field. There is no way of knowing how many machines have been repaired and adjusted as a result of attendance at meetings and spread of influence through dealers and leading farmers. Some estimate that over one-half those attending meetings perform one or more of the suggestions offered by the engineer. About 1500 machines are reported to have been kept in service by the program instead of junked or traded for new ones. One hundred pounds of steel used for repairs on an existing machine will usually offset one ton of steel used in the construction of a new machine.

AN ESTIMATED TWO AND ONE-HALF MILLION POUNDS OF STEEL SAVED BY THIS PROGRAM

3 It is estimated that 2,500,000 lb of steel have been saved by this program in showing farmers how to repair and adjust their equipment to keep it running. A large part of this saving is due to the reduction in wear as a result of correct adjustment, lubrication, and preventive maintenance. One engineer estimates the saving of 9,000 gal of fuel and an 8 per cent increase in the life of tractor tires during the spring planting season as a result of instructions given at fifteen tractor tuneup meetings.

4 The district agricultural engineers have been responsible for the adoption of the buck rake for harvesting the hay crop. Reports show that approximately 535 rakes have been constructed and operated as a result of meetings, publicity, farm visits, and distribution of construction plans. Economic surveys show that this new haying tool will save 1.4 man-hours per ton over the use of the wagon and hay loader equipment. Assuming that these rakes were used on average farms they have saved 57,750 man-hours for their owners. Labor for harvesting hay is seasonal and very difficult to secure for a short time. Many tons of hay were harvested with these rakes which otherwise would have been left in the field.

5 Thousands of bushels of small grains have been saved by instructions given on combine adjustments at field meetings. One custom operator combined 1,000 acres during the year. The machine was checked and found to be throwing away 5 bu for every acre combined. One-half hour spent in adjusting the machine brought the waste down to a matter of kernels per acre.

6 One farm machinery branch warehouse report shows that farmers cooperated in the program by "purchasing repair parts early." This branch states that their sales for 1942 as compared to 1941 were as follows: January, 253 per cent increase; February, 313 per cent increase; March, 56 per cent increase; April, 34 per cent increase; May, 7 per cent decrease; June, 7.2 per cent decrease, and July, 31 per cent increase. As new machines became scarce the repair parts sales increased.

Future Program. The winter months will find one day and one-half day discussion meetings woven into a schedule of farm machinery repair clinics all over the state. Considerable interest is showing in the community repair centers where local repair facilities are inadequate. Four of these centers have been established where farmers have cooperated in renting a building each sharing the cost of heat and electricity. Here they bring their machines and work on them together. They get help from each other and from the machinery dealers when they need it. The district engineer comes to the center twice each month to help them and discuss repairs and adjustments with them. They see the possibility of this becoming a permanent setup.

A few dealers are allowing farmers to bring their machines to their show rooms and work on them under the supervision of the dealer's service man. This gives the dealer more parts business, and the farmer does the cleaning, dismantling, and assembling. The serviceman's time is spent on special jobs requiring more skill and many more machines are overhauled during the slack winter season. Incidentally, the farmer learns to appreciate the problems of the dealer in servicing and charging for service which seemed excessive before he tackled some of the overhaul work himself.

Since all the machines that farmers own will not be overhauled this winter, the engineers may perform more service calls in 1943 and fewer field demonstrations. They have established their reputations and will probably devote more and more of their time to the actual need of getting a broken-down machine back into operating condition.

"Production Rating of Farmers Under Wartime Conditions"

(Continued from page 74)

hours per acre somewhat. However, this could by no means justify a 5½ to 1 ratio between weighted production units of these two crops. I note that all grain crops are weighted low in comparison to corn and that flax, another war crop of low acre yield and high value per bushel, is given only two-thirds the production units per 100 bu as corn. It seems to me that there is something screwy about these figures, but perhaps the committee has very good reasons unknown to me for arriving at the factors in column 6. If you would care to bring my viewpoint to the attention of the committee, I would be very glad to get further enlightenment as to methods used in arriving at these results.

On our particular farm we are all right as far as equipment is concerned. The man power situation is bad. As fast as I can get a man and train him to handle our equipment, the draft board grabs him, or he goes into defense work at wages far higher than a farmer can afford to pay. The fourth man I have had in less than a year left last week for a city job, leaving me all alone on a 360-acre, high yielding farm. That is too big an order, even for an agricultural engineer.

Sorry I could not attend the A.S.A.E. fall meeting at Chicago in December; was still busy then riding the corn picker.

FRED W. HAWTHORN

EDITOR'S NOTE: Mr. Hawthorn is a graduate agricultural engineer, a member of the A.S.A.E., and a successful Monona County (Iowa) farmer.

Essentials of a Farm Type Frozen Food Cabinet

By E. C. Meyer

MEMBER A.S.A.E.

THE INTEREST of REA in the development of suitable equipment for the home freezing and storage of foods can be attributed largely to two factors — first, (1) the recognition that a home unit possesses certain important advantages over other systems, especially for rural users, and (2) the knowledge based on past experiences that we are in a unique position to give good developments the impetus they deserve. The 850 REA electric systems, most of them cooperatives, with more than a million consumers are in an enviable position to command the interest, cooperation, and respect of the best research and manufacturing facilities of the country.

We are convinced that the home freezer and storage chest, which can be located and operated on the owner's premises, will in many cases have important advantages over the community locker plant. Passing over the less important ones, we feel that for those people who store the products from their own farms the home unit is essential to insure economical preservation of quality foods. Products are generally not available in large enough lots to justify a trip to the community storage, and accumulation of larger lots over a period of time is usually not a recommended practice.

A leading scientist whose special interest is the freezing of fruits and vegetables told us of a series of simple questions by means of which he invariably determines the reason for failure to produce satisfactory frozen products. First he asks, "What variety was used?"; next, "What was the degree of maturity?"; and last, "What was the source?" The first question is probably of least concern to us in evaluating its effect on quality of product stored in a home unit as compared to a locker plant. The second and third are, however, very important. Products reach the correct stage of maturity over a period of some time and the only way to get them stored at the best time is to do it in small lots. The home unit lends itself to this. As to the third question, which relates to source, the scientist wishes to point out that satisfactory frozen foods can generally not be produced except from home-grown products, harvested and carried through the processing stages in a minimum of time. He claims that the most important factor controlling the quality of fruit and vegetables is the time interval and conditions existing between picking or digging and the point at which the temperature is reduced to a figure at which bacteriological and enzymatic action is reduced to a safe minimum.

At this point it might be of interest to describe briefly the procedure which is followed in developing and making available new equipment to our members. Following a thorough study of the item under consideration, specifications are prepared which are reviewed by the Technical Standards Committee. If approved, they form the basis for bids by interested manufacturers on lots of usually several thousand, which represent a pooled order from a number of cooperatives.

Our investigation of both the equipment on the market and the literature on the subject of freezing and storage of foods left us with a feeling that certain of the requirements were either not very rigid or that they were far from completely established. We received answers to some twenty questionnaires sent to research institutions in which we asked the various experts to give us their opinion of the time within which such products as beef, pork, poultry, fish, vegetables, and fruit should be frozen, allowable temperature fluctuations during storage, and the storage temperature. We also asked to what temperature and in what time should cooling to some point above storage temperature be carried in the event it was permissible to transfer the product from the freezing to the storage compartment before storage temperature had been attained. While the published literature generally emphasized rapid freezing but avoided specific figures, our questionnaire returns almost invariably gave us specific figures but of a wide variation.

For example, in the eighteen comments relating to the freezing and storing of beef, five gave no requirement on freezing time: One said freeze as quickly as possible; one said fast freezing not practical; two said time of freezing of little importance; and one gave no answer. Those who gave specific answers gave the following figures: One said 2 hr; one, 4 hr; three, 6 hr; one, 6 to 8 hr; two, 8 hr; one, 16 hr; one, 18 to 24 hr; and three, 24 hr. The number considering 8 hr or less to be the most desirable was equal to those favoring 8 hr or more.

On the question of the desirable storage temperature for beef there was better agreement. Here only two gave no answer; one said to 10 F; one, 10 F or less; thirteen, 0 F; and one, 5 F below.

On the question of allowable temperature fluctuation, four gave no answer; two said plus or minus 1 deg; one, plus or minus 1½ deg; five, plus or minus 2 deg; three, plus or minus 2½ deg; and three, plus or minus 5 deg.

On the question of what temperature to cool beef to and in what time if it is to be transferred to storage before reaching storage temperature, five gave no answer; one definitely recommended a single compartment storage; five recommended bringing to storage temperature immediately; one said drop to 10 F but gave no time; one, 10 to 12 F but gave no time; one, 10 F in 12 hr; one 10 F in 18 hr; one, 15 F in 4 hr; one, 15 F in 12 hr; and the last, 20 F in 5 hr.

In general, the agreement and disagreement on questions relating to other products was in line with the results just discussed.

Our investigations indicated clearly that a number of phases of the freezing and storage problem were not settled. At the same time we knew that such storage was being carried on in both locker plants and home units with considerable success, so that it appeared that the time had been reached for some rather extensive field tests under a wide variety of conditions. The chief and the assistant chief of our technical standards division are both firm adherents to the theory that once research has been developed to a reasonable degree much faster progress can be made by letting some of the ultimate users make observations and criticisms based on actual use.

Because of a feeling that those commercially available units with which we were familiar were out of reach of most of our cooperative members, we began on the job of

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devising one which would meet the essential requirements which would be of economical, simple, and durable construction, and which could be sold through our group purchase system for less than $300. We feel this has been successfully accomplished with the willing and able assistance of a manufacturer.

Upon completion of the unit we felt that it would be essential to give it a thorough test both to determine its capacity and to secure the necessary data upon which to base operating instructions for prospective users. Concerning commercial units on the market, we were rather surprised to find that of these manufacturers with whom we had an opportunity to discuss their products, none had put their units through a series of actual tests simulating field production. Perhaps they were justified in this, considering the wide difference of opinion on such questions as allowable freezing time, but it did appear to us that some testing was essential if reasonably accurate operating instructions were to be prepared. This job, which required several months of intensive effort, was accomplished through the cooperation of the U. S. Bureau of Home Economics in their research laboratories at Beltsville, Md.

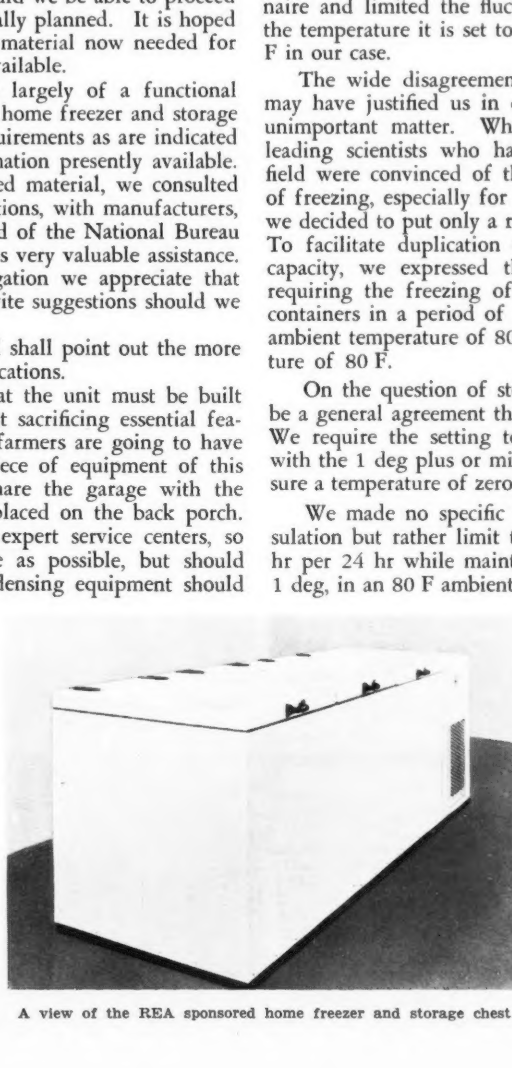
As a result of this work we felt able to set up specifications which might be used to govern bids which interested manufacturers might make should we be able to proceed on an order of 2500 as we originally planned. It is hoped to go through with it as soon as material now needed for more important war activities is available.

Our specifications, which are largely of a functional nature, are intended to describe a home freezer and storage chest which conforms to such requirements as are indicated to be essential by the best information presently available. In addition to reviewing published material, we consulted with specialists of experiment stations, with manufacturers, with personnel of the USDA, and of the National Bureau of Standards, all of whom gave us very valuable assistance. Even with our thorough investigation we appreciate that we are not infallible and thus invite suggestions should we be in error about any point.

In the next few paragraphs, I shall point out the more important features of the specifications.

We emphasize first of all that the unit must be built just as simply as possible without sacrificing essential features. We recognize that not all farmers are going to have a clean, dry place to house a piece of equipment of this size, so it may be forced to share the garage with the family car or possibly even be placed on the back porch. Not all farms are accessible to expert service centers, so the unit must be as troublefree as possible, but should any difficulties develop, the condensing equipment should be readily replaceable by locally available mechanics and without factory facilities.

With reference to the cabinet, we feel that it should be of the top-opening type. It will have a volume of approximately 20 cu ft, with the freezing compartment taking possibly one-quarter of this. We feel this to be a satisfactory size principally for two reasons: (1) we are interested in promoting a size which will have maximum acceptance so that costs may be kept at a minimum, and (2) it is not our thought that such a unit is to replace other methods of food preservation but rather to supplement them. Since the unit may be located in the home, it must be possible to move it through a 30-in door, and because it will probably not be moved frequently, we have no objection if it is necessary to tip it on its side, or if lids or other projecting parts be so constructed that they can be removed to permit passage through a door. We feel that the inside should be readily accessible both for purposes of loading and unloading and to permit cleaning, so we require that the lids uncover not less than 75 per cent of the top area. Material and construction of interior surfaces, shelving, etc., are left to the manufacturer with the requirement that they be sanitary, easily cleaned, and noncorrosive.



A view of the REA sponsored home freezer and storage chest

Concerning the condensing unit, if a cylinder type compressor is used, it must have at least two cylinders, be readily accessible, and be driven by a $\frac{1}{2}$-hp, 60-cycle, 120-v, single-phase, capacitor-start, induction-run motor equipped with a built-in overload protective device.

Tests at various institutions show that of utmost importance is a uniform temperature if dessication and dehydration of products is to be held to a minimum. We went beyond the requirement indicated by our questionnaire and limited the fluctuation to 1 deg plus or minus the temperature it is set to maintain, which is minus 1 deg F in our case.

The wide disagreement as to allowable freezing time may have justified us in deciding that this is a relatively unimportant matter. When we found that at least two leading scientists who had done a lot of work in this field were convinced of the relative unimportance of rate of freezing, especially for a unit to be used as we planned, we decided to put only a reasonable limitation on this time. To facilitate duplication of a test to check the freezing capacity, we expressed the capacity in terms of water, requiring the freezing of 45 lb placed in 47 paper cup containers in a period of 14 hr. This is to be done in an ambient temperature of 80 F with an initial water temperature of 80 F.

On the question of storage temperature there seems to be a general agreement that zero is necessary and desirable. We require the setting to be made at minus 1 F which, with the 1 deg plus or minus allowable fluctuation, will insure a temperature of zero or lower at all times.

We made no specific requirement as to amount of insulation but rather limit the energy consumption to 4 kw-hr per 24 hr while maintaining minus 1 F, plus or minus 1 deg, in an 80 F ambient.

In the matter of warranty we require the customary one-year guarantee for the entire unit plus an additional two years for the cabinet because we feel that the construction should be such that the manufacturer is willing to back it for that period of time. Realizing the effect on thermal conductivity and possibly even the fit of lids and shape of cabinet, which would attend the condensation and accumulation of moisture in the walls, we felt justified in making this requirement.

Community Fruit and Vegetable Dehydrators

By John A. Schaller
MEMBER A.S.A.E.

DEHYDRATION of fruits and vegetables is being brought into prominence by the demands of the present emergency, particularly in regard to commercial dehydration plants for supplying the dried foods needed for the armed forces and for lend-lease. But what about civilian needs? It appears likely that farm families and in particular operators of community canning plants will be limited in their canning operations because of a possible shortage of tin cans for food preservation.

To meet the need for information relating to the dehydration of food products as a community enterprise, the Tennessee Valley Authority, in cooperation with the Tennessee Agricultural Experiment Station, the Georgia Agricultural Experiment Station, and the Georgia Division of Vocational Agricultural Education, is conducting intensive studies on the development and adaptation of equipment and techniques for dehydrating southern grown fruits and vegetables. There are two reasons for conducting this research:

1 The community canneries in the southeastern states, of which there are approximately 550, may be faced with a conversion of their normal canning operations to some other method of preservation because of the need for conserving tin plate used in the manufacture of tin cans. The present emphasis is toward dehydration, which could not be successfully developed without having basic information on proper equipment and operating techniques. The necessary technical information for an expanded program was not available and had to be determined through actual studies on a community scale.

2 It was realized that the successful development or adaptation of equipment and techniques for food dehydration would permit the saving of substantial quantities of agricultural products that could be used for home consumption, thereby relieving commercially processed food for other civilian needs and military requirements.

The objectives of this research program are (1) to develop or adapt equipment, using the least amount of critical materials, for dehydrating products on a community scale similar to present operation of community canning plants, (2) to determine through research studies the preparation, processing, storage, refreshening, and cooking methods best adapted, (3) to determine the operating cost of the equipment and the economic value to the community, and (4) to make this information available to interested educational agencies for use in 1943 to encourage maximum practical use of this method of food preservation as part of the war effort.

Paper presented December 8, 1942, at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill. A contribution of the Rural Electric Division. Author: Associate agricultural engineer, Tennessee Valley Authority.

A cabinet type dehyrator was designed to fit into existing community plants where preparation equipment and steam boilers were already available. In selecting materials of construction particular attention was given to the use of non-essential materials as far as possible and still secure a workable, safe, and reasonably economical unit, and to the use of building materials available locally. This design utilizes commercial unit heaters and fans of known output and commercial control equipment.

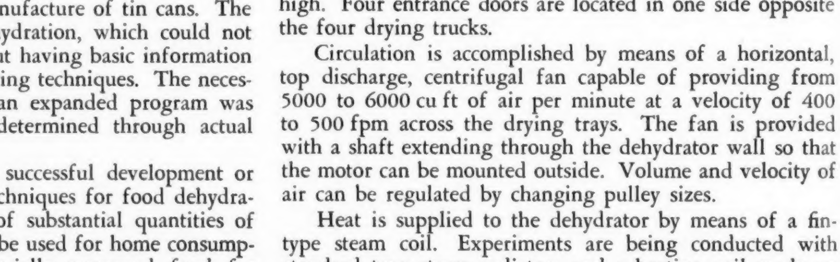
This dehydrator (see accompanying drawing) consists of two parts—a top section or fresh and return air duct, containing the heating unit, fan, and air intake damper, and a bottom section or drying tunnel, containing four drying trucks each loaded with 18 3x4-ft slatted wood trays and air exhaust damper. The cabinet is of wood-frame construction with ½-in insulating board on the inside and tongue-and-groove boards on the outside, and the inside dimensions are approximately 4 ft wide 17 ft long, and 8 ft 9 in high. The heating tunnel is approximately 2 ft 10 in high and the drying tunnel is approximately 5 ft 7 in high. Four entrance doors are located in one side opposite the four drying trucks.

Circulation is accomplished by means of a horizontal, top discharge, centrifugal fan capable of providing from 5000 to 6000 cu ft of air per minute at a velocity of 400 to 500 fpm across the drying trays. The fan is provided with a shaft extending through the dehydrator wall so that the motor can be mounted outside. Volume and velocity of air can be regulated by changing pulley sizes.

Heat is supplied to the dehydrator by means of a fin-type steam coil. Experiments are being conducted with standard type steam radiators and a heating coil made up of ordinary 1 to 2-in pipe to determine if these can be adapted for this purpose.

The temperature is controlled by a motor-operated steam valve which in turn is regulated by a dry bulb thermostat, which can be adjusted to the required temperature.

The humidity is controlled by regulation of the intake and exhaust dampers. Both dampers are closed at the beginning of the dehydration period until the product is heated thoroughly to approximately the wet bulb temperature of the air. In actual operation it has been found that approximately 10 to 20 per cent fresh air is all that is required. Manual operation of the dampers has been found sufficient when operating on a community scale, pro-



(Left view) This community dehydrator consists of two parts: (1) top section, or fresh and return air duct, containing the heating unit, fan, and air intake damper, and (2) bottom section, or drying tunnel containing four drying trucks loaded with 18 3x4-ft wood trays, and an exhaust air damper • (Right view) Open end view of community dehydrator showing fan assembly and how trucks enter dehydrator.

TABLE 1. CAPACITY OF 50-BU DEHYDRATOR FOR VARIOUS PRODUCTS AND EVAPORATION DATA*

Material	Specific heat of material	Capacity: Fresh product Bu	Fresh product Lb. Per bu	Fresh product Lb. Total	Prepared product lb	Prepared product Per cent moisture content	Tray loading lb/sq ft	Dry Product Lb total	Dry Product Lb per bu	Dry Product Per cent moisture content	Average drying time, hr	Weight of water to evaporate Total lb	Weight of water to evaporate Lb per hr
Peaches (peeled)	.92	50	50	2500	1700	89.0	2.36	212	4.24	11.8	16	1488	93.00
Apples	.92	40	50	2000	1225	87.5	1.70	175	4.37	12.5	12	1050	87.00
Pears	.91	38	56	2128	1225	87.0	1.70	180	4.74	11.5	12	1045	87.00
Beans (green)	.91	45	30	1350	1080	89.5	1.50	120	2.67	5.5	14	960	68.50
Okra		42	32	1344	1080	91.3	1.50	100	2.38	6.0	10	980	98.00
Corn**		83	42	3486	1080	71.0	1.50	337	4.06	7.0	10	743	74.30
Carrots	.87	28	50	1400	1080	90.5	1.50	108	3.86	5.0	10	972	97.20

* The above data are based on actual figures at the Clarksville, Georgia, dehydration plant.
** Fresh product on basis of ear corn, including cobs and husks. The prepared weight is for the kernels.

vided a hydrometer placed on the exhaust side of the drying tunnel is used for checking the temperature and humidity of the air leaving the product.

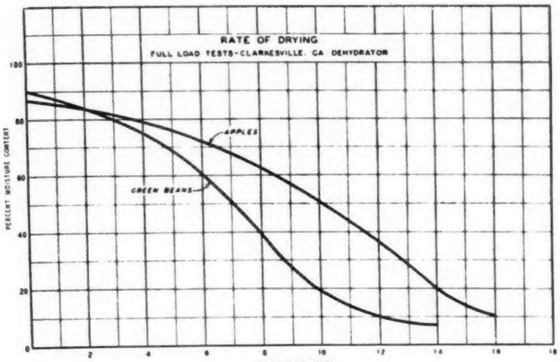
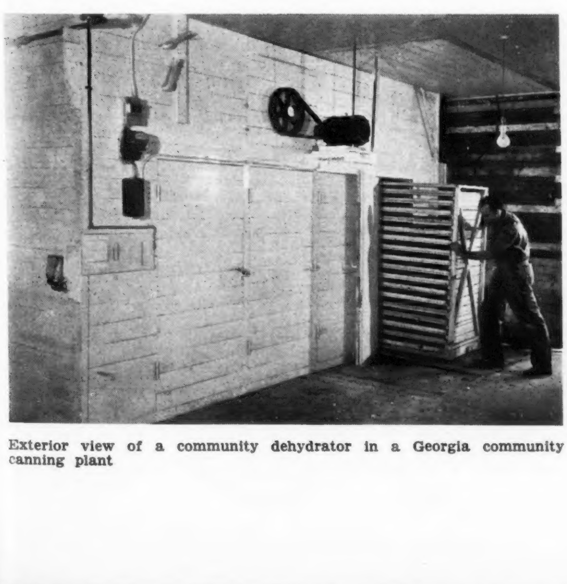


FIG 2

This dehydrator has a capacity of 50 bu of prepared peaches. Capacities for other products, along with data on tray loading, weights of fresh and dried products, average drying times, and weight of water evaporated are contained in Table 1.

The approximate cost (less labor, without steam boiler) is $502.70; cost per ton capacity, $405.00; cost per square foot of tray surface, 70 cents. An attempt is being made to further reduce this cost by substituting plywood for metal in the construction of baffles and fan housing and at the same time reduce the amount of critical materials used.

Detailed studies of operating characteristics and performance were made at the Clarksville, Georgia, plant. The capacity of this plant was approximately 85 per cent of the capacities listed in Table 1. During the period July 28 to October 15, when experimental data were collected, a total of 115 families used the dehydrating facilities for preserving approximately 18 to 20 different fruits and vegetables.



Exterior view of a community dehydrator in a Georgia community canning plant

Table 2 contains operating data collected during full load tests on green beans and apples. In Fig. 2 per cent moisture content is plotted against drying time and indicates rate of drying.

The community acceptance of this method of food preservation, in connection with the four installations in community canning plants, has been very good. Considerable interest has been shown by many communities throughout the Southeast in the installation of similar equipment.

It is felt that enough studies have been made on design of equipment for dehydration and on preparation techniques to initiate a program for 1943. Packaging and storage studies are now being made. Information resulting from this research will be made available to prospective operators of community plants before next drying season.

It is estimated that the following annual savings in metal can be effected by converting community canning plants (on the basis of the plant packing an average of 41,900 equivalent No. 2 cans) *(Continued on page 88)*

TABLE 2. FULL LOAD TESTS OF COMMUNITY DEHYDRATOR ON GREEN BEANS AND APPLES

General	Green Beans	Apples
Variety	Tender pod, stringless	Staymen Winesap
Stage of maturity	Beans in pod, half mature	Firm to mellow
Market grade	A No.1	Ungraded No. 2
Price per bushel	$1.25	$1.00
Number of bushels dried	32	31
Processing Procedure		
Preparation	Ends broken off and beans broke into several pieces	Hand peeled, cored, and cut in sixteenths
Washing	Wash thoroughly in cold water	Washed before preparation
Treatment	Blanched in hot water for 10 min (190 to 200F)	Sulphured for 30 min. after placed on trays
Tray loading	1.5 lb per sq ft	1.83 lb. per sq ft
Drying time	14 hr	16 hr
Drying temperature	145 F	145 F
Weights of Products		
Fresh product	968 lb	1550 lb
Prepared product	884 lb	1050 lb
Prepared product after treatment	849 lb	
Dry weight (total)	79.75 lb	166 lb
Dry weight per bushel	2.5 lb	5.35
Moisture Content		
Prepared product	92.5 per cent	87 per cent
Prepared product after treatment	90.0	
Dried product	6.8	10.0
Total Moisture Removed	769.25 lb	892.0 lb
Condensate Data		
Average coil pressure	11.8 lb	16.7 lb
Average condensate per hr	117 lb.	133 lb
Total condensate for test	1523 lb	2132 lb
Cost of Operation		
Power consumption (motor)	16.7 kw-hr	18.35 kw-hr
Total fuel (coal) used	538 lb	558 lb
Total water (condensate) used	182 gal	256 gal
Cost of operation* per lb. prepared product	.36 c	.33 c
Cost of operation per lb. dried product	4.0 c	2.1 c
Btu and Boiler Horsepower Required		
Btu output	130,260	148,456
Boiler horsepower	3.89	4.43

*Includes water at $1.50 per 1,000 gal, electricity at 4c per kw-hr, and coal at $8.50 per ton.

A Converted Subsurface Tiller

By L. F. Larsen and E. C. Joy

ASSOCIATE MEMBER A.S.A.E.

THE rapid adoption of subsurface tillage by South Dakota farmers has created a large demand for suitable machinery to do this work. To lower farm costs many attempts have been made to convert present farm tillage machinery into subsurface tillers.

Some manufacturers have sweeps that can be attached to the beam of any lister, most of which are satisfactory for subsurface tillage.

The South Dakota Agricultural Experiment Station has tried two methods of converting the conventional tractor plow to a subsurface tillage machine. The first was to use a regular two-bottom 14-in plow by placing a third beam on the right-hand side of the plow. Two 24-in sweeps were then fastened on the two back beams with one 12-in sweep on the front or center beam. This made a total cut of 52 in. Next a tool bar made from an old railroad rail was placed across the plow with a shank and a 24-in sweep mounted on each end as illustrated in Fig. 1. The total width of cut was thereby increased to 92 in.

The regular power lift was utilized by attaching an adjustable linkage between the land axle and furrow axle. This replaced the original leveling lever connection as can be seen in Fig. 3.

A semifloating hitch was constructed which made possible the removal of the rear furrow wheel as illustrated by Fig. 2.

Two difficulties were encountered during field tests of this machine. First, the wheels were too close together for good depth control of the two outside sweeps, and, second, when operated in heavy stubble residue, as shown in Fig. 3, the beams were too close together and easily clogged with trash.

It was then decided to try an entirely different arrangement. The same two-bottom plow was used with the beams spread 42 in apart, center to center. A heavy angle iron was used as a tie bar, and a diagonal brace added for rigidity. An extension was made on the front beam spreader and also on the cross hitch bar as illustrated in Fig. 4.

The land axle and furrow axle were fastened together as one solid axle with provision for individual depth adjustment. All changes were made on the tiller with the wheels blocked up to simulate normal working depth. The same semifloating hitch was used.

Two 45-in Pence sweeps, originally made for a McCormick-Deering lister, were mounted as in Figs. 5 and 6.

The above plan resulted in a simple and satisfactory subsurface tiller which could be easily and quickly reassembled for conventional plowing.

The satisfactory operation of this tiller is shown by its successful performance in heavy stubble residue shown in Figs. 4 and 6, as there were no clogging difficulties experienced.

Article prepared especially for AGRICULTURAL ENGINEERING. A contribution of the A.S.A.E. Committee on Weed Control — C. W. Smith (chairman), L. F. Larsen, E. A. Hardy, and H. P. Smith. Authors: Respectively, assistant professor of agricultural engineering, South Dakota State College and assistant agronomist, Soil Conservation Service, U. S. Department of Agriculture.

Community Fruit and Vegetable Dehydrators

(Continued from page 87)

to dehydration. (Basic data on metal requirements for tin cans and glass jars were supplied by the Container Section, Office of Civilian Supply, WPB.)

1 In comparison with canning in tin, 5 tons of tin plate (5.2 tons after the first year as the steel investment in the plant will be retired) will be saved.

2 In comparison with canning in glass, over 1,040 lb of steel used in lids will be saved. (Assume lid bands will be used 3 years.)

Fig. 1 This shows the method of attaching beam, tool bar, shanks, and sweeps of subsurface tiller • Fig. 2 Semifloating hitch construction • Fig. 3 The tiller working in thick stubble • Fig. 4 This shows the bracing arrangement used • Fig. 5 Showing how the 45-in sweeps were mounted • Fig. 6 This view shows work done by sweeps which have been raised out of the ground.

Reference Books for Agricultural Engineering

By F. A. Brooks
MEMBER A.S.A.E.

AGRICULTURAL engineers apply the practices of many specialized branches of engineering to solve physical and economic problems in the very complex industry of the life sciences. Thus we could well use all the knowledge of both the physical and life sciences, except that no one has that capacity. At a recent A.S.A.E. meeting, we were ridiculed as not being engineers because we did not know the exact energy requirement for some minor duty. Of course, agriculture does not use energy in exact parcels, so such a tirade reveals at least the lack of understanding of the critic. But he might have thought better of our profession if there existed an orderly compilation of technical data peculiar to agricultural engineering.

There are certain data and fields of knowledge which are distinctly agricultural engineering, specifically A.S.A.E. standards; Nebraska tractor tests; field implements and mechanized field operations; housing and control of livestock; and produce handling, storing, and processing. For instance, reference books of other engineering branches do not include the power requirements for chopping hay, the ventilation needs for dairy barns, the water use of various crops, or the sun-drying of fruit. But many other problems of agricultural engineers involve the same variables worked with by other engineers. Some of these problems are directly parallel and, although some require a special agricultural bent, we find the material for solving these more general engineering problems in the reference books already published in other engineering branches.

Some members who have thorough fundamental training in applied physics and have good memories may object to the use of handbooks because they prefer to develop more specific reference material from current literature. This is a better method if one has time and adequate library facilities. But then one is faced by specialized use of words and often formulas which are dimensionally incomplete. The easiest method of verifying, say, the dropping of a gravitational constant, is by reference to comparable expressions in the appropriate technical handbook. Hence one cannot often afford time to go beyond the handbook into reading specialized literature outside one's own field unless the refinements of latest investigations may alter the concept of one's own problem.

Of course many members rarely need a handbook, except for trigonometric problems and standardized elements, because their textbooks give adequate theoretical treatments and their duties do not require them to go beyond the factual material they have acquired in their own work. This, however, is far from the case of agricultural engineers who are expected to find quick answers to any question in the physical sciences (which some tell us must be easy because we're not bothered by the variabilities of life processes!) The technical handbooks are admirable for most of such questions, and in addition they furnish reliable answers to many minor problems in research projects, thus clearing one's mind for the main problem.

In this discussion of reference books now in use by our members, the ultimate purpose is to reach some decision as to what the proposed A.S.A.E. Data Book need *not* include. Then in choosing contents for our book we can concentrate primarily on subjects distinctly of an agricultural-engineering nature.

So the question at hand is: *What current reference books are readily available to our membership?* In other words, what books can be considered as companion volumes to the proposed A.S.A.E. Data Book, so that the subjects they treat can be excluded from our book? Some topics, of course, too briefly treated for us, may need expanded retreatment, as for instance—weather, surface climate, and soils. Other topics, frequently referred to, may warrant restatement in condensed form, such as characteristics of fuels and lubricants.

As a sure beginning let us consider "Machinery's Handbook" (The Industrial Press), or its competitor: Colvin's and Stanley's "American Machinists' Handbook" (McGraw-Hill). These contain shop practice information absolutely essential to everyone concerned with mechanical design or the use of machine tools. Briefly they contain:

Mathematical Tables—Powers, Roots, Reciprocals; Various Data of Circles and Other Shapes; Trigonometric Functions; Logarithms
Mechanics and Strengths of Materials
Engineering Standards—Fits, Tolerances; Bolts, Screws, and Wrenches; S. A. E. Materials; Ball Bearings, etc.
Power Transmission—Gears, Chains, Belts, Clutches, and Brakes
Pipe and Pipe Fittings; Flow of Air and Water in Pipes
Springs, Wire Cable, Hooks
Machine-Tool Operation—Speeds, Feeds; Jigs and Fixtures; Grinding
Hand Tools—Taps, Dies, Drills, Milling Cutters, Reamers, etc.
Heat Treatment; Welding

Next we might consider the technical handbooks for the major engineering groups: mechanical, electrical, and civil. Each of these categories approximates the professional groups of our Society, namely, Power and Machinery, Rural Electrification, Farm Structures, and Soil and Water Conservation. Is it not reasonable to assume that each of our members will have at hand a technical handbook of the major engineering field most specific for his special interest? This would mean that our specialist in, say, Power and Machinery would have a mechanical engineers' handbook which provides the necessary data for solving all the common problems in that field, and gives brief treatments for other major engineering fields. Then the crucial question is this: Given a problem not adequately treated in a bordering field, for instance in electricity, would he go and get an electrical handbook or would he expect an A.S.A.E. Data Book to give him the answer because it applies to agriculture? Unless he is willing to go to the appropriate major reference book in the other field, or to consult with someone experienced in that field, his demand for A.S.A.E. data could not be met without great duplication in every major field of engineering.

The cost of this duplication is prohibitive. It is therefore necessary that we bear in (*Continued on page 92*)

Paper presented June 30, 1942, at the 35th annual meeting of the American Society of Agricultural Engineers at Milwaukee, Wis. A contribution of the Research Committee of the College Division. Author: Agricultural engineer, California Agricultural Experiment Station, Davis, Calif.

Reference Books for Agricultural Engineering

(Continued from page 90)

mind that if we are to have any A.S.A.E. Data Book it cannot include common engineering material.

The reference books in the three mentioned engineering categories whose contents might well be excluded from an A.S.A.E. Data Book are:

Mechanical Engineers' Handbook, Kent (Wiley); Mechanical Engineers' Handbook, Marks (McGraw-Hill).

Electrical Engineers' Handbook, Pender and Del Mar (Wiley); Standard Handbook for Electrical Engineers, Fowle (McGraw-Hill).

Civil Engineers' Reference Book, Trautwine (Trautwine Co., Ithaca); American Civil Engineers' Handbook, Merriman (Wiley); Architects' and Builders' Handbook, Kidder & Parker (Wiley).

The above three sets of handbooks have much duplication of material although written for different fields of engineering. Their contents cannot be described adequately in brief fashion, but in general terms they include for each field the following treatments: Mathematical tables; mensuration; fundamental theories of the various branches of the applied science used in that field, and in briefer form those of neighboring fields; experimental data establishing various constants and criteria; and standard practices.

CONSIDERATION SHOULD BE GIVEN TO THE BEST GENERAL ENGINEERING HANDBOOKS

Some members not concerned with machine shop practice may find Machinery's Handbook unnecessary because of the treatment of machine elements in the mechanical engineers' handbooks. Such preferences in individual selection would, however, have no effect on selection of material for an A.S.A.E. Data Book, because if the briefer treatment is adequate for that member, he would not expect amplified treatment in our book.

Consideration should be given to the general engineering handbooks, especially for the A.S.A.E. members who are not specializing in the mechanical, electrical, or civil engineering branches. Two of these are: Handbook of Engineering Fundamentals, Eshbach (Wiley) and General Engineering Handbook, O'Rourke (McGraw-Hill).

These are designed explicitly to contain the general information needed in all branches of engineering. One of these without the specialized handbooks might be an adequate companion volume for an A.S.A.E. book. Briefly, both these general books contain: Mathematical tables; physical properties of materials; mechanics and thermodynamics; fluid flow, and electricity and magnetism. Eshbach also includes a section on chemistry, and O'Rourke expands on structures, water supply, etc.

None of the reference books cited so far are of much assistance to engineers in the processing field who are concerned with heat and mass transfer, change of state, and chemical transformations. For these, the Chemical Engineers' Handbook, edited by Perry (McGraw-Hill) is outstanding. This handbook is very broad and where, for instance, the mechanical and civil engineering books deal with flow of air and of water, this chemical engineering book treats all fluids by appropriate attention to pertinent physical properties. On the whole, the chemical engineers seem to have their more extensive data better generalized than have mechanical engineers. The equations in the Chemical Engineers' Handbook for various phenomena are taken directly from the accepted current literature, hence the only sacrifice for generalization is the omission of extensive tables for specialized cases. The graphs of empirical data are of small scale, and the nomographs for physical constants cannot be read as precisely as tables. However, the universal applications in this book practically refute the old objection to handbooks—of putting one's thinking into a groove.

The section headings in the second edition of the Chemical Engineer's Handbook are:

Mathematical Tables and Weights and Measures; Mathematics; Physical and Chemical Data.

Indicators, Qualitative Analysis, Catalysis, Organic Chemistry; Physical and Chemical Principles.

Flow of Fluids; Heat Transmission; Evaporation; Humidification, Dehumidification, and Cooling Towers and Spray Ponds.

Gas Absorption and Solvent Extraction; Absorption; Distillation and Sublimation; Drying.

Mixing of Materials; Mechanical Separations; Crushing, Grinding, and Pulverizing.

Measurement and Control Process Variables; Materials of Construction; High-Pressure Technique; Movement and Storage of Materials.

Fuels; Power Generation and Mechanical Power Transmission; Refrigeration.

Electricity and Electrical Engineering; Electro Chemistry.

Economic Factors in Chemical Plant Location; Accounting and Cost Finding; Safety and Fire Protection; Reports and Report Writing.

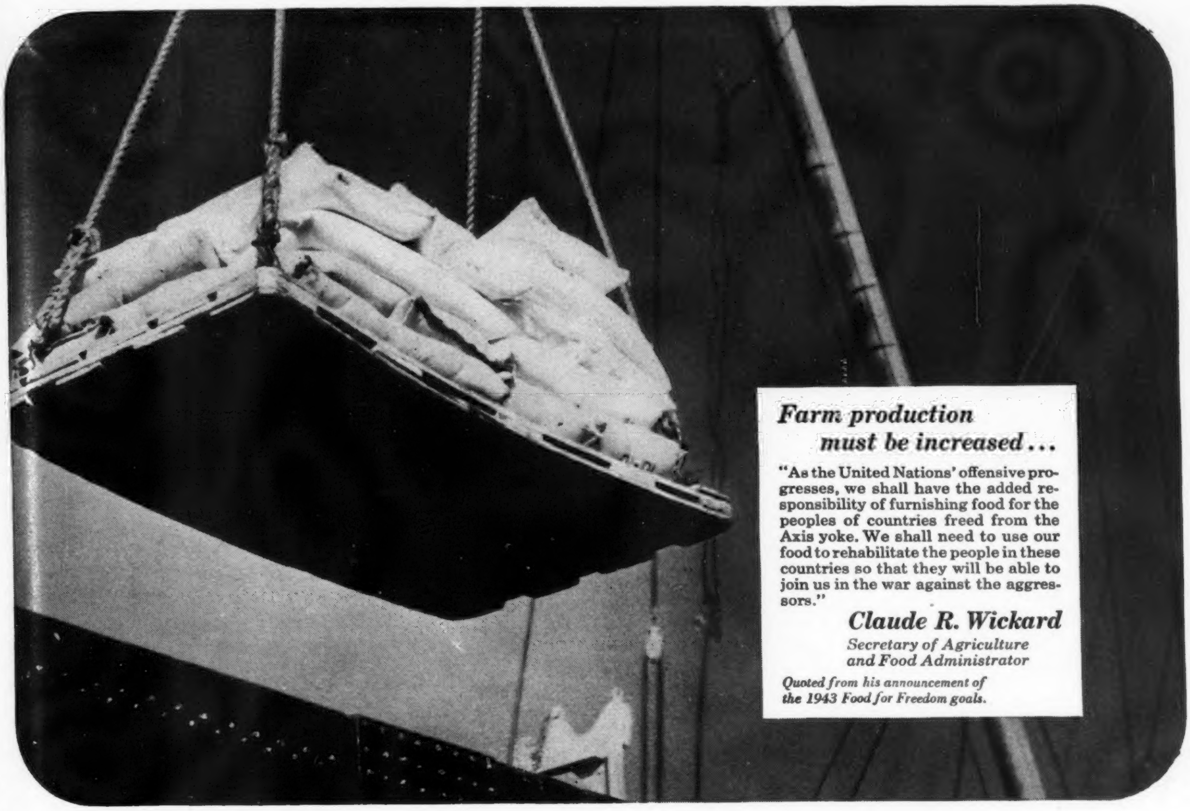
From the above list it is seen that only a few sections are not of interest to agricultural engineers, but that several subjects important to us are not included. Briefly, these are machine elements, mechanics, and structures.

If it may be assumed that these missing subjects are adequately covered in such books as Machinery's Handbook and O'Rourke, the acceptance of these with the Chemical Engineers' Handbook would establish very extensive technical references for agricultural engineers. Then, bearing in mind the availability of other major reference books, the subjects needing treatment in the proposed A.S.A.E Data Book would be so distinctly agricultural engineering, that our book would have a unique character; and, of most importance, could be started on a scale modest enough for financing within the Society.

All of the foregoing discussion applies only to the engineering side of our profession. This seems appropriate because we are primarily engineers. However, we work in agriculture and hence we do need agricultural data. This subject should be discussed in the near future even though it is very much more complex than that of the engineering references.

Synthetic vs. Natural Rubber

ONE permissible generalization is that no synthetic yet produced has all the properties of natural rubber. For this reason the replacement of the natural material can be accomplished only with knowledge of and proper selection of the synthetic best fitted for the particular use. While some of the comparisons are unfavorable to the synthetics, it is altogether fortunate that there are some important items on the asset side of the ledger for these man-made materials. By proper selection and compounding, synthetics having more oil resistance, more chemical resistance, and more heat resistance than natural rubber can be obtained. In the matter of cold resistance, natural rubber is generally better but there are a few very fortunate exceptions. The synthetic substances depend upon such plasticizers as do not stiffen appreciably at low temperatures, and some of the best ones for low temperatures are not suitable at high temperatures.—E. G. Kimmich in *Mechanical Engineering* for February 1943.



How your job helps our boys win battles

A WELL FED SOLDIER makes a better fighting man. And when he is fighting in a foreign land, victory comes more quickly if the civilian population is well fed, too—is on his side.

The tremendous task of feeding our armed forces, our allies, and the peoples of occupied countries calls for a miracle in farm production. Every existing farm machine must be kept running at peak efficiency in order to do it.

Only experts like yourself are competent to do the job of maintaining farm equipment. It's an obligation you owe both the farmers in your community and the nation.

Remember, whenever you overhaul a low compression tractor by installing high altitude pistons and switching to gasoline, the farmer can get up to 30 per cent more power.

Where an overhaul is not needed, point out that even in a low compression tractor, changing from kerosene or distillate to gasoline will produce up to 12 per cent more power if *cold* type spark plugs are installed and the manifold changed to the *cold* position.

The Ethyl Corporation has published an interesting book entitled, "High Compression Overhaul and Service." If you have not already received a copy, write to the Agricultural Division, Ethyl Corporation, Chrysler Building, New York, N.Y.—manufacturer of antiknock fluids used by oil companies to improve gasoline.

FARM POWER IS FIGHTING POWER

MAKE EVERY OVERHAUL A HIGH COMPRESSION OVERHAUL

NEWS SECTION

Farm Chemurgic Conference

THE Ninth Annual Chemurgic Conference of Agriculture, Industry, and Science will be held at the Drake Hotel, Chicago, Illinois, March 24 and 25. The theme of the conference is to be "Chemurgy in War," and the entire program will stress the importance of chemurgy in providing many of the essential raw materials that are so vital to the war effort.

The Conference will be opened with a luncheon on March 24, the speaker at which will be Wheeler McMillen, president of the National Farm Chemurgic Council, and editor-in-chief of "Farm Journal and Farmer's Wife." This will be followed by a general session devoted to rubber in the war, at which brief reports will be made by outstanding authorities representing various manufacturers of this most essential product. All varieties of rubber will be discussed at length. An evening session on March 24 will be devoted to the general subject of alcohol at war, in which will be included discussion of new processes in alcohol production.

During the forenoon of March 25 there will be two concurrent sessions, one devoted entirely to fibers and the other to plastics, and two concurrent sessions during the afternoon will be concerned with fats and oils and with forest products.

A series of special luncheons will be held March 25, sponsored by various organizations concerned with chemurgic problems, among which will be a luncheon sponsored by the American Society of Agricultural Engineers at the Knickerbocker Hotel one block from the Drake. Members and friends of the Society are invited to attend this luncheon.

A special soybean dinner and round table is being scheduled for the dinner hour on March 25, and this will be followed by an evening session devoted to the general subject of new crops for war and peace, featuring such special subjects as waxy corn and waxy grain sorghums, drug plants, chemurgic rubber crops, spices from American acres, and development of paprika plants in the Carolinas.

Copies of the program and other information regarding the conference may be obtained from the main office of National Farm Chemurgic Council, 50 West Broad Tower, Columbus, Ohio.

More Washington Changes Affecting Agricultural Engineering

ON February 23rd the U. S. Department of Agriculture announced some major changes in two bureaus of the Agricultural Research Administration. One of these changes involved the transfer of agricultural engineering research, and also the research of chemical wood eradication and effluent contaminants from the Bureau of Agricultural Chemistry and Engineering to the Bureau of Plant Industry. The latter bureau will hereafter be known as the Bureau of Plant Industry, Soils, and Agricultural Engineering.

The other change transfers the direction of the four regional research laboratories to the Bureau of Agricultural Chemistry and Engineering, which bureau will hereafter be known as the Bureau of Agricultural and Industrial Chemistry.

Recently the rural electrification investigations activity of the former Bureau of Agricultural Chemistry and Engineering was transferred to the Division of Farm Mechanical Equipment, of which R. B. Gray is chief. This division is now a part of the new BPISAE and is located at North Laboratory, Beltsville Research Center, Beltsville, Md.

Bibliography on Frozen Foods

A PARTIAL bibliography on the subject of frozen foods has been compiled by John E. Nicholas, nationally recognized authority on refrigeration engineering, as a contribution of the Committee on Frozen Foods of the American Society of Agricultural Engineers, of which Mr. Nicholas is chairman.

This bibliography is in mimeograph form and copies of it may be obtained by members of A.S.A.E. without charge on request to Society headquarters.

A.S.A.E. Meetings Calendar

June 21 to 23—Annual Meeting, Purdue University, Lafayette, Ind.

December 6 to 8—Fall Meeting, La Salle Hotel, Chicago, Ill.

Pacific Coast Section Officers

AT THE meeting of the Pacific Coast Section of the American Society of Agricultural Engineers held at Logan and Salt Lake City, Utah, February 5 and 6, the following Section officers were elected for the ensuing year: Chairman, J. E. Christiansen, irrigation and drainage engineer, Regional Salinity Laboratory, USDA; first vice-chairman, O. W. Sjogren, sales manager, Killefer Manufacturing Corp.; second vice-chairman, R. A. Work, associate irrigation engineer, (SCS), U. S. Department of Agriculture; third vice-chairman, A. C. Jacquot, head, agricultural engineering department, Utah State Agricultural College; secretary-treasurer, Walter W. Weir, drainage engineer, University of California. Hobart Beresford, University of Idaho, is the newly elected member of the executive committee, and O. W. Israelsen, retiring section chairman, becomes ex officio member of the executive committee. The new nominating committee of the Section is S. W. McBirney, W. W. McLaughlin, and L. J. Smith.

"Hydrologic Data"

SEVERAL members of the American Society of Agricultural Engineers are included in the list of those who collected and prepared the data for a bulletin issued this year under the above title which constitutes the second of a series of annual bulletins presenting basic hydrologic data collected at the North Appalachian Experimental Watershed near Coshocton, Ohio, by the Hydrologic Division, Office of Research, U. S. Soil Conservation Service. This particular project is one of several in the United States at which hydrologic problems as affected by agricultural practices within the field of the Soil Conservation Service are being studied. A.S.A.E. members who are credited with participation in the work on the bulletin are W. D. Ellison, project supervisor; W. H. Pomerene, assistant agricultural engineer; C. E. Ramser, chief, Hydrologic Division, and H. S. Riesbol, formerly engineer in charge of hydraulic investigations on the project.

Personals of A.S.A.E. Members

Donald H. Anderson was recently promoted from the position of sales promotion manager to that of sales manager of Aermotor Co. He has been with this company since he graduated in agricultural engineering from Iowa State College in 1935.

Henry E. Berns, who has been employed in the service department of Massey-Harris Co., is now an instructor in aviation at the Naval Training School conducted by the U. S. Navy Department at Chicago.

Stanley Bidlack and *Joseph S. Webb*, agricultural engineers, Philadelphia Electric Co., recently completed a series of farm publications on the effective use of electric power in farm work under wartime conditions, covering the following subjects: Electric Service and the Farmer, Mechanical Ventilation of Farm Buildings, Saving Help and Increasing Production on Poultry Farms with Electricity, Motors for Farm Use, and Electric Help for Dairymen.

Robert C. Burnette is now serving as senior commodity standards specialist, industrial and agricultural machinery section, Standards Division, Office of Price Administration, Washington.

Benjamin O. Childs is now employed as an associate agricultural engineer of the U. S. Soil Conservation Service and is located at Montpelier, Vt. He was previously employed by the Bureau of Agricultural Chemistry and Eengineering in Texas and Louisiana.

(Continued on page 96)

Personals of A.S.A.E. Members

(Continued from page 94)

J. Robert Dodge formerly associate architect in the Bureau of Agricultural Chemistry, U. S. Department of Agriculture, has been assigned to the hemp division of the Commodity Credit Corporation (USDA) in the capacity of industrial architect and is engaged in supervising the erection of a hemp mill for CCC.

Herman J. Finkel has been advanced from junior engineer to assistant civil engineer, Engineer Corps, Great Lakes Division, U. S. Army.

Robert E. Hartsock was recently transferred from his position as designing engineer in the gun mount division of J. I. Case Co., to the aircraft division of the same company, where he is in charge of inspection.

Keith Hinchcliff, extension rural architect, Mississippi State College, is author of pamphlet, entitled "Dairy Building Remodeling Suggestions and Estimates for Meeting Grade A Milk Standards." It is designated as Ex. M. 11.723-1.

W. C. Hulburt was recently promoted from assistant to associate agricultural engineer in the Bureau of Agricultural Chemistry and Engineering, USDA. He is employed at the Agricultural Engineering Laboratory, Beltsville Research Center, Beltsville, Md.

E. N. Humphrey is on leave as assistant agricultural engineer, University of Idaho, and is serving as chief instructor at the Mt. Rainier Ordnance Automotive School at Tacoma, Wash.

C. H. Jefferson, assistant professor of agricultural engineering, Michigan State College, is author of an article, entitled "Orchard and Potato Spray Rigs in Rural Fire Protection," which appeared in the November 1942 issue of the Michigan Agricultural Experiment Station quarterly bulletin.

Mack M. Jones and *Lloyd E. Hightower*, agricultural engineers, University of Missouri, are joint authors of Circular 252, entitled "Rental Rates for Farm Machines," recently issued by that institution.

J. B. Kelley, agricultural engineer, University of Kentucky, is author of Circular No. 53, entitled "How to Make a Thresher for Castor Beans," recently issued.

M. A. R. Kelley, agricultural engineer, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture, is author of leaflet No. 231, entitled "Blackout of Poultry Houses and Dairy Barns," recently issued by the USDA.

Frank Kranick, research engineer, J. I. Case Co., is author of a series of practical, timely articles on farm machinery currently appearing in "Implement and Tractor," which comprise the revised edition of his book "Farm Equipment for Mechanical Power." This series is backed by long experience in the development, design, and application of farm machines by a nationally recognized authority and will be of particular interest to agricultural engineers.

M. R. Lewis, senior agricultural engineer, Soil Conservation Service, USDA, has been loaned to the Emergency Rubber Project in charge of the Forest Service. He will have supervision of the preparation of land to be planted to guayule for irrigation and of irrigation on guayule plantations.

J. Dewey Long, for the past few years agricultural engineer, Douglas Fir Plywood Association, and prior to that professor of agricultural engineering, University of California, was recently made chief of the new research department of the Association. This department maintains a research laboratory at Tacoma, which at present is being used largely for a number of projects relating directly to the wartime contributions of the Douglas fir plywood industry. It is expected, however, that shortly several small projects of agricultural application will get under way, which phase of the laboratory's activities will be expanded as the pressure of special wartime work is eased.

Wayne H. Lowry recently accepted a position with the advertising department of International Harvester Co., and will be located at Bettendorf, Iowa. His new work has to do with the preparation of operator's manuals and service catalogues for Harvester war equipment. He was previously assistant agricultural engineer with the U. S. Soil Conservation Service.

George C. Marti, recipient of an Inter-American Trade Scholarship, after a short period of orientation at the USDA Beltsville Research Center, will enter a progressive training program at the McCormick Works of the International Harvester Company at Chicago. On completion of the training program he will be qualified to engage in agricultural engineering work in Latin America.

Xzin McNeal, until recently camp supervisor for the Arkansas Department of Education, was recently appointed instructor in agricultural engineering, specializing in farm buildings, at the University of Arkansas, Fayetteville. His duties will include research in addition to resident instruction work.

Lee C. Prickett is now an electrical engineer with the intelligence branch of the Chief of Engineers office, U. S. War Department. His particular work is the preparation of strategic studies on electrical facilities in areas of interest. He was transferred to the War Department from the Rural Electrification Administration.

Sam Shiozawa, until recently classed as a "trainee," now has the rating of junior engineer with the Rural Electrification Administration and is located at Saint Louis, Missouri.

E. A. Silver, until recently associate agricultural engineer of the Ohio Agricultural Experiment Station, is now chief agricultural engineer of that station.

L. J. Smith and *J. Roberts* members of the agricultural engineering staff, State College of Washington, are listed as two of the authors of the 18th Annual Progress Report of Investigations of Various Uses of Electricity for Agriculture in the State of Washington, recently issued by the Washington Committee on the Relation of Electricity to Agriculture.

Archie A. Stone, chief, farm equipment and tractor section, machinery branch, Office of Price Administration, will broadcast over Radio Station WGY at Schenectady on March 26. His subject is "The Triumph of the Engineer," and he will discuss the contributions of agricultural engineers in the present world crisis.

William H. Tamm was recently promoted from assistant engineer to associate engineer and made assistant head of the design and drafting section of the U. S. Engineer Office at Norfolk, Virginia.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Truman W. Billings, manager, iron and steel division, Coop. G. L. F. Farm Supplies, Inc., Terrace Hill, Ithaca, N. Y.

Norval H. Curry, field engineer, Structural Clay Products Institute, Ames, Iowa. (Mail) 120½ Welch Ave.

Rollo O. Dobbs, district engineer, (SCS) U. S. Department of Agriculture. (Mail) 836 5th East St., Apt. No. 15, Salt Lake City, Utah.

Joe F. Hixon, agricultural engineer, Alabama Power Co., Montgomery, Ala.

Robert A. Knight, power sales and service engineer, Pennsylvania Power Co. (Mail) 194 Main St., Greenville, Pa.

Glenn O. Olson, agricultural engineer, Texas Agricultural Experiment Station, College Station, Tex. (Mail) Box 2007.

James A. Ullom, engineering division, Brown & Root Construction Co. (Mail) Cactus Ordinance Plant, Etter, Tex.

TRANSFER OF GRADE

Robert C. Burnette, senior commodities specialist, farm machinery section, standards division, Office of Price Administration. (Mail) Apt C-211, 3111 20th St., N., Arlington, Va. (Junior Member to Member).

Eldon M. Collins, assistant agricultural engineer, (SCS) U. S. Department of Agriculture. (Mail) 1816 W. 7th St., Red Wing, Minn. (Junior Member to Member)

W. H. Farmer, associate irrigation engineer (guayule emergency rubber project) U. S. Department of Agriculture. (Mail) P. O. Box 831, Bakersfield, Calif. (Junior Member to Member)

William B. Nivison, senior administrative officer, (REA) U. S. Department of Agriculture. (Mail) Boatmen's Bank Bldg., St. Louis, Mo. (Junior Member to Member)

Ordean E. Olson, state agricultural conservation engineer, (AAA) U. S. Department of Agriculture. (Mail) 1647 Broadway, Fargo, N. D.

Agricultural Engineering Digest

A review of current literature by R. W. Trullinger, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers at the address indicated.

Oil Filters for Internal-Combustion Engines, *C. W. Smith, T. B. Johnson,* and *E. L. Munter.* Nebraska Ag. Exp. Sta. (Lincoln), Bul. 334 (1941). A brief introduction defines the full flow and bypass methods of installation, the various filtering principles represented by commercial filters, and centrifugal, centripetal, and parallel flow through the filtering element, and describes the various filtering materials currently used.

The filter testing equipment is made up of six testing units, of which one is shown in two diagrammatic drawings and the assembly in photographs. All units are identical in design. One filter testing unit consists essentially of a sump; gear pump; sediment bowl with 16-mesh screen; electric heater; agitator; pressure gage; thermometer; the necessary cocks, valves, pipe fittings, etc.; and one commercial filter to be tested, all assembled on a tripod and the tripod mounted to a sliding platform by means of which it may be pulled into the driving belt from a line shaft driven by a 3-hp motor. The sump consists of a section of 6-in iron pipe, with a cone-shaped bottom formed by cutting and welding. The sump has a capacity of approximately 14 lb of oil, not including the capacity of the attached filter to be tested. Eleven pounds of oil was used as a standard charge for testing purposes which left ample room for agitation, foaming, and expansion. The outlet from the sump to the pump is taken from the apex of the cone-shaped base, leaving no pockets in which sediment can collect. Oil returns to the sump, both directly from the pump and from the filter. That portion of the oil going directly from the pump back to the sump is comparable with that oil of an engine which goes directly from the pump to the bearings and then to the engine sump. This passage on the testing equipment can be throttled to make the resistance comparable with that of the bearings. The oil going through the filter being tested follows a path identical with that of a bypass filter installation on an engine. The oil was heated to 140 F while circulating through the bypass system before being admitted into the filter circuit. Bus crankcase oil was used as the dirty oil for these tests, and the first tests were made by starting with dirty oil. Later tests were made by starting with clean oil and comparing the ability of the various filters to keep it clean while an addition to the testing unit slowly added dirty oil (2 qt during 20 hr) to each sump. Methods used for tests and analyses of the oil during test runs are described, and photographs of hourly spot tests from 1 to 20 hr indicate the oil-clearing performances of each of 30 filters. Performance as measured by various other criteria is shown in charts and tables.

A great variation in the efficiencies of oil filters was found. Large filters were more efficient than small ones. The rate of flow of oil through filters varied greatly. In the filters tested there was no close correlation between rates of flow and filter efficiencies.

Hydrologic Studies of the Putah Creek Area In the Sacramento Valley, California, *M. R. Huberty* and *C. N. Johnston.* California Ag. Exp. Sta. (Berkeley), 14 (1941), No. 3. The college of agriculture at Davis is located within the Putah Creek Basin. In years of low rainfall, the underground basin is its sole source of water supply. The division of irrigation has observed underground-water conditions on the university farm for a long time.

Although shallow wells are affected by deep wells, their water-level fluctuations are in general out of phase with the deeper well levels, and they normally have water elevations higher than those of deep wells nearby. In such areas as reclamation district 999, where shallow-water strata are under pressure, surface layers may receive some water from the pressure-bearing strata below. Most of the ground-water supply of Putah Creek lower basin enters through the porous gravel beds near the head of the fan, in the vicinity of Winters. This area is potentially a great spreading basin. Although underground-water levels in the area north of Winters have been raised since 1912 by the use of the Capay Canal water, other parts of the area have had drops in water levels of from 15 to 25 ft during the period. This lowering does not represent an overdraft, but rather the changes in head resulting from increased pumping. In dry periods, the recession is greater than usual. The recharge is good during years of normal or above-normal rainfall.

The boron content of the well waters varies widely. Cache Creek water imported into the district has had a marked influence upon some well waters. The data secured indicate a possible method of studying underground water movements. The underground water temperatures are uniform throughout the basin for all but the deepest wells, which tend to be several degrees warmer than the others.

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